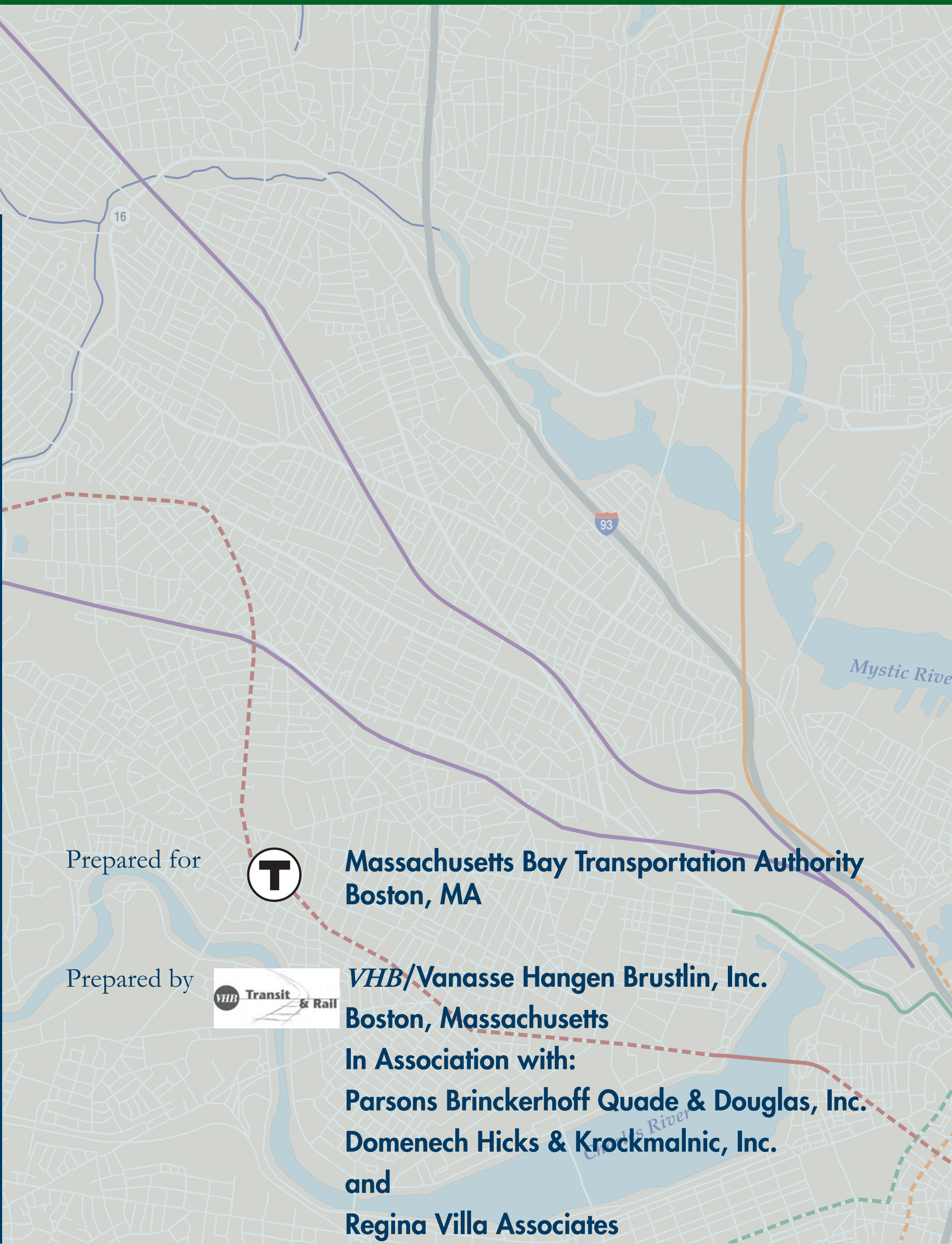
Major Investment Study/Alternatives Analysis

Beyond Lechmere Northwest Corridor Study

Cambridge, Somerville, Medford, Massachusetts



Prepared for

Massachusetts Bay Transportation Authority
Boston, MA

Prepared by

VHB/Vanasse Hangen Brustlin, Inc.
Boston, Massachusetts
In Association with:
Parsons Brinckerhoff Quade & Douglas, Inc.
Domenech Hicks & Krockmalnic, Inc.
and
Regina Villa Associates

mabos.8959cov.indd

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DRAFT

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Somerville

Lee Auspitz
Todd Blake
Walter Booth
John Cole
Scott Darling
Seth Goldstein
James Kostaras
Jeffrey Levine
Joe Lynch
Jim McGinnis
Ellin Reisner
Nelson Salazar
Alderman Tom Taylor
Lucy Warsh
Alderman Bill White
Rick Willette

Cambridge

Jeff Bennett
Mary Ann Donofrio
Larry Parnell
Catherine Preston
Susanne Rasmussen
Jason Schrieber

Medford

Melissa Bennett
Douglas Carr
Paul De Stafano
Lauren DiLorenzo
Robert Feigin
Geraldine Freda
Mary Giordano
Anna Kissinger
Ken Krause
Barbara Rubel

Boston

Richard Garver
Vineet Gupta

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DANIEL A. GRABAUSKAS, MBTA General Manager

DENNIS A. DIZOGLIO, MBTA Asst. General Manger for Planning, Real Estate & Environmental Affairs

JOSEPH M. COSGROVE, MBTA Director of Planning

MBTA DIRECTOR OF PLANNING

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Table of Contents

Beyond Lechmere Northwest Corridor Study

Acknowledgements vii

1 Introduction 1-1

1.1 Major Investment/Alternatives Analysis Overview 1-1
1.2 Study Background 1-1
1.3 Historical Perspective 1-2
1.4 Overview of Study Area 1-3
1.5 Relationship to the FTA Planning and Project Development Process 1-4
1.6 Community Involvement 1-5
  1.6.1 Advisory Group 1-5
  1.6.2 Public Meetings 1-5

2 Purpose and Need 2-1

2.1 Project Purpose 2-1
2.2 Need for Transportation Improvements 2-1
  2.2.1 Transit Access and Mobility 2-2
  2.2.2 Transit Capacity 2-2
  2.2.3 Air Quality 2-3
  2.2.4 Sustainable Development/Smart Growth 2-3
  2.2.5 Environmental Justice 2-4
2.3 Goals and Objectives 2-4
  2.3.1 Imrove Regional Mobility 2-4
  2.3.2 Expand Transit Access and Intermodal Connections 2-5
  2.3.3 Improve Air Quality and Minimize Environmental Impacts 2-5
  2.3.4 Provide Services to Environmental Justice Populations 2-5
  2.3.5 Advance Sustainable Development/Smart Growth Principles 2-6
  2.3.6 Maximize Transportation Efficiencies 2-7

3 Existing Conditions 3-1

3.1 Description of Study Area 3-1
3.2 Overview of Transportation Faciilities and Service in Corridor 3-2
3.3 Source Documents 3-3
3.4 Demographics and Travel Behavior 3-4
  3.4.1 Population 3-5
  3.4.2 Population and Health 3-6
  3.4.3 Population and Employment 3-8
  3.4.4 Travel Behavior for Residents 3-8
  3.4.5 Travel Behavior for Workers 3-10
  3.4.6 Environmental Justice 3-15
    3.4.6.1 EJ Guidelines 3-15
    3.4.6.2 Study Area EJ Communities 3-19
3.5 Roadways 3-20

3.5.1 Major Roadways 3-20
3.5.2 Congestion Management Areas 3-24
3.6 Transit Services 3-27
3.6.1 Bus Service 3-28
3.6.1.1 Bus Safety and Comfort 3-30
3.6.1.2 Loading Evaluation 3-30
3.6.1.3 Service Reliability Standards 3-31
3.6.1.4 Schedule Adherence Evaluation 3-31
3.6.1.5 Bus System Improvements 3-32
3.6.2 Green Line (Rapid Transit/Light Rail) 3-33
3.6.3 Red Line (Rapid Transit/Heavy Rail) 3-36
3.6.4 Orange Line (Rapid Transit/Heavy Rail) 3-37
3.6.5 Commuter Rail Services 3-39
3.6.5.1 New Hampshire Main Line 3-39
3.6.5.2 Fitchburg Division 3-40
3.7 Development Patterns 3-42
3.7.1 Economic Development/Land Use 3-42
3.7.1.1 Existing Land Use Patterns 3-42
3.7.1.2 Economic Development Initiatives 3-44
3.7.2 Transportation Corridors 3-45
3.7.3 Environmental Considerations 3-47
3.8 Coordination with Other Projects 3-47
3.8.1 North Point Area 3-48
3.8.2 Twin City Plaza Expansion 3-48
3.8.3 Assembly Square 3-48
3.8.3.1 Yard 21 3-49
3.8.3.2 Assembly Square Mall 3-49
3.8.3.3 Stop & Shop Supermarket 3-49
3.8.3.4 Winter Hill Yacht Club 3-50
3.8.3.5 IKEA Site 3-50
3.8.4 Somerville Community Path 3-50
3.8.5 Union Square Master Plan/Phase II 3-51
3.8.6 Transportation Improvement Projects 3-51
3.8.7 Planning Studies and Regulatory Initiatives 3-52
3.8.8 Additional Private Developments 3-54

4 Identification and Evaluation of Alternatives – Tier 1 4-1

4.1 Overview of Alternatives Identification and Evaluation Process 4-1
4.2 Development of Tier 1 Alternatives 4-2
4.3 Description of Tier 1 Alternatives 4-2
4.3.1 Green Line Alternatives 4-3
4.3.2 Bus Rapid Transit Alternatives 4-8
4.3.3 Commuter Rail Alternative 4-13
4.4 Tier 1 Evaluation and Screening 4-15
4.4.1 Screening Process 4-15
4.4.2 Screening Criteria 4-16
4.5 Tier 1 Findings 4-18

5 Identification and Evaluation of Alternatives – Tier 2 5-1
5.1 Development of Tier 2 Alternatives 5-1
5.1.1 Identification of Tier 2 Alternatives 5-1
5.1.2 Methodology for Tier 2 Alternatives Development 5-2
5.1.2.1 Conceptual Alignments 5-3
5.1.2.2 Operating Plans 5-3
5.1.2.3 Capital Improvements 5-3
5.1.2.4 Conceptual Capital Costs 5-4
5.1.2.5 Conceptual Operating and Maintenance Costs 5-9
5.2 Description of Tier 2 Alternatives 5-11
5.2.1 Alternative 1A: Green Line Extension to West Medford 5-11
5.2.1.1 Conceptual Alignment 5-11
5.2.1.2 Operating Plan 5-13
5.2.1.3 Capital Improvements 5-13
5.2.1.4 Conceptual Capital Costs 5-18
5.2.1.5 Conceptual Operating and Maintenance Costs 5-18
5.2.2 Alternative 1C: Green Line Extension to West Medford & Union Square .. 5-19
5.2.2.1 Alignment 5-19
5.2.2.2 Operating Plan 5-21
5.2.2.3 Capital Improvements 5-22
5.2.2.4 Conceptual Capital Costs 5-23
5.2.2.5 Conceptual Operating and Maintenance Costs 5-23
5.2.3 Alternative 2B: BRT to West Medford, Green Line to Union Square 5-24
5.2.3.1 Alignment 5-24
5.2.3.2 Operating Plan 5-26
5.2.3.3 Capital Improvements 5-27
5.2.3.4 Conceptual Capital Costs 5-32
5.2.3.5 Conceptual Operating and Maintenance Costs 5-32
5.2.4 Alternative 3A and 3B: Commuter Rail Shuttle Service 5-33
5.2.4.1 Alignment 5-33
5.2.4.2 Operating Plan 5-35
5.2.4.3 Capital Improvements 5-36
5.2.4.4 Conceptual Capital Costs 5-41
5.2.4.5 Conceptual Operating and Maintenance Costs 5-41
5.2.5 Alternative 4: Transportation System Management 5-42
5.2.5.1 Alignment 5-42
5.2.5.2 Operating Plan 5-44
5.2.5.3 Capital Improvements 5-45
5.2.5.4 Conceptual Capital Costs 5-45
5.2.5.5 Conceptual Operating and Maintenance Costs 5-45
5.3 CTPS Travel Demand Modeling 5-46
5.3.1 Methodology and Assumptions 5-46
5.3.2 Model Results 5-47
5.3.2.1 Ridership and Revenue 5-48
5.3.2.2 Highway and Vehicular Travel 5-49

5.3.2.3 Air Quality 5-49
5.3.2.4 Environmental Justice 5-50
5.3.2.5 User Benefit 5-50
5.4 Tier 2 Evaluation 5-52

6 Next Steps 6-1

6.1 Next Steps 6-1
6.2 Areas for Further Study 6-2

Appendices

Tier 1 Detailed Evaluation Tables .... A
Locus Maps of Proposed Station Areas .... B
Conceptual Capital Cost Estimate Detail C
Conceptual Operations and Maintenance Cost Estimate Detail .... D
CTPS Memo on Beyond Lechmere Modeling Methodology .... E
CTPS Travel Demand Model Detailed Results .... F

Figures

Figures ....

Figure 1-1 Project Study Area 1-4
Figure 3-1 Study Area Neighborhoods and Squares.. 3-2
Figure 3-2 Study Area Census Tracts 3-5
Figure 3-3 Mass EOEA Environmental Justice Populations.. 3-17
Figure 3-4 Boston MPO Environmental Justice Target Areas...................................... 3-18
Figure 3-5 Study Area Environmental Justice Communities 3-20
Figure 4-1 Alternative 1A – Conceptual Alignment... 4-4
Figure 4-2 Alternative 1B – Conceptual Alginment... 4-5
Figure 4-3 Alternative 1C – Conceptual Alignment 4-6
Figure 4-4 Alternative 1D – Conceptual Alignment 4-7
Figure 4-5 Alternative 2A – Conceptual Alignment... 4-9
Figure 4-6 Alternative 2B – Conceptual Alignment... 4-10
Figure 4-7 Alternative 2C – Conceptual Alignment 4-11
Figure 4-8 Alternative 2D – Conceptual Alignment 4-12
Figure 4-9 Alternative 3 – Conceptual Alignment 4-14
Figure 5-1 Alternative 1A – Conceptual Alignment... 5-12
Figure 5-2 Typical Section: Proposed LRT with Commuter Rail 5-15
Figure 5-3 Typical LRT Station Plan and Evaluation.. 5-16
Figure 5-4 Typical LRT Station Section.. 5-17
Figure 5-5 Alternative 1C – Conceptual Alignment 5-29
Figure 5-6 Alternative 2B – Conceptual Alignment... 5-31
Figure 5-7 Typical Section: Proposed BRT with Commuter Rail 5-28
Figure 5-8 Typical BRT Station Plan and Evaluation (Center Platform)....................... 5-20
Figure 5-9 Typical BRT Station Plan and Elevation (Staggered Platform)................... 5-29
Figure 5-10 Typical BRT Station Sections... 5-30
Figure 5-11 Alternative 3 – Conceptual Alignment 5-34
Figure 5-12 Typical Section: Commuter Rail with Proposed Third Track....................... 5-38
Figure 5-13 Typical Commuter Rail Station Plan and Elevation.................................... 5-39
Figure 5-14 Typical Commuter Rail Station Section.. 5-40
Figure 5-15 Alternative 4 – Conceptual Alignment 5-43

Tables

Tables

Table 3-1 Population and Demograhics by Census Tract 3-6
Table 3-2 Population and Health Status Indicators 3-7
Table 3-3 Population and Employment 3-8
Table 3-4 Commute Travel Behavior for Residents 3-9
Table 3-5 Travel Behavior Data for Workers 3-10
Table 3-6 Travel Modes to Work by Census Tract 3-11
Table 3-7 Auto Availability by Census Tract 3-12
Table 3-8 Travel Times to Work by Census Tract 3-14
Table 3-9 Environmental Justice Criteria Applied by Census Tract 3-19
Table 3-10 Bus Service Frequency and Ridership 3-30
Table 3-11 MBTA Bus Loading Standards 3-30
Table 3-12 Summary of Bus Schedule Adherence Standard 3-31
Table 3-13 Green Line Typical Weekday Boardings (1997) 3-35
Table 3-14 Green Line Car Requirements and Headways 3-36
Table 3-15 Red Line Typical Weekday Station Entrances (1997) 3-37
Table 3-16 Orange Line Typical Weekday Station Entrances (1997) 3-38
Table 3-17 Lowell Line Daily Weekday Boardings by Station 3-40
Table 3-18 Fitchburg Line Daily Weekday Boardings by Station 3-41
Table 4-1 Summary of Tier 1 Screening 4-17
Table 5-1 Alternative 1A Conceptual Travel Times 5-13
Table 5-2 Alternative 1C Conceptual Travel Times 5-21
Table 5-3 Alternative 2B Conceptual Travel Times 5-26
Table 5-4 Alternative 3A Conceptual Travel Times 5-35
Table 5-5 Alternative 3B Conceptual Travel Times: Anderson RTC Commuter Rail Shuttle 5-35
Table 5-6 Alternative 3B Conceptual Travel Times: Lowell Line Commuter Rail Service 5-36
Table 5-7 Summary of CTPS Regional Travel Model Results 5-51
Table 5-8 Summary of Quantitative Indicators Developed for Tier 2 Evaluation 5-53
Table 5-9 Comparison of Tier 2 Alternatives – Quantitative Indicators 5-55
Table 5-10 Summary of Tier 1 Ratings in Qualitative Evaluation Categories 5-56

1

Introduction

1.1 Major Investment Study/Alternatives Analysis Overview

The purpose of the Massachusetts Bay Transportation Authority's (MBTA's) Beyond Lechmere Northwest Corridor Major Investment Study/Alternatives Analysis (MIS/AA) is to define the most appropriate transit investment strategy for improving mobility and regional access for residents in the northwest corridor communities of Cambridge, Somerville and Medford. The Beyond Lechmere Northwest Corridor Study investigates cost-effective transit solutions that will increase transit accessibility, improve corridor mobility, increase transit ridership, improve regional air quality, ensure equitable distribution of transit services, and support opportunities for smart growth initiatives and sustainable development.

The MIS/AA offers the opportunity to evaluate the various modes of transit services and alternative alignments that will meet the needs of the study area. It is the goal of this MIS/AA to identify conceptual routing options, operational characteristics, environmental issues, costs, and design constraints. Additionally, the MIS/AA allows an opportunity for stakeholders to participate in an open and collaborative planning process.

1.2 Study Background

Improvements to transit service in the study area have been the subject of several studies over the past 40 years. One of the objectives of the 1962 North Terminal Area Study was to "design a new transit alignment to permit a future branch extension (of the Green Line) to Somerville and communities northwest along the right-of-way of the Boston and Maine Railroad". The 1973 Boston Transportation Planning Review Northwest Study focused on this issue by identifying and evaluating various bus, commuter rail, and Green Line extension alternatives in the "Somerville Radial Corridor". In 1981, the MBTA conducted the Green Line Northwest Project Study, which provided an evaluation of transit alternatives beyond Lechmere Station.

In the late 1980s, the MBTA advanced the design of a relocated Lechmere Station to the eastside of Monsignor O'Brien Highway. This new station would have provided commuter parking as well as a storage facility for trolleys. This project was halted due to funding constraints. In 2000, the MBTA signed a public-private partnership agreement that provides for the relocation of Lechmere Station.

The Commonwealth of Massachusetts, in obtaining environmental permits for the Central Artery/Tunnel (CA/T) Project in the early 1990s, committed to implementing a number of Boston region transit improvement projects as mitigation measures. The transit project commitments included a Green Line Extension to Medford Hillside. The September 2000 Administrative Consent Order, which updated the original 1991 agreement, specified a December 2011 date for completion. In early 2005, the Administrative Consent Order was again amended and included a provision specifying a process for reevaluation and possible substitution of the three remaining transit commitment projects, one of which was Green Line Extension to Medford Hillside. The project reevaluation process taking account of air quality benefits and Boston Region Metropolitan Planning Organization priority-setting review criteria is scheduled to be completed in 2005

1.3 Historical Perspective

The area encompassed by this study has a long history of transit usage. The Boston region's first street railway consisted of a single car, which in 1852 began service between Harvard Square and Union Square in Somerville. Over the next 50 years, routes and services were continuously expanded, typically following existing paths and roadways. By the early 1900s, a network of streetcar lines had evolved which served to shape the structural pattern of residential and commercial development throughout the area. The routes also evolved to provide connections to the Main Line Elevated at Sullivan Square. In Somerville, these streetcar routes were located on Broadway, Boston Avenue, College Avenue, Highland Avenue, Main Street, Medford Street, Pearl Street, Beacon Street, Summer Street, Washington Street, Somerville Avenue, Webster Avenue, Cross Street, Holland Street and Elm Street. The routes also extended north into Medford Square along High Street, Main Street and the Fellsway Line.

Many of these streetcar routes continued in operation into the 1940s, when they were converted to trackless trolley operation. The Clarendon Hill – Lechmere routes on Highland and Somerville Avenues operated upwards of 110 trip runs per day in the 1940s. These routes are continued today as part of the MBTA's local bus network.

Rapid transit services were provided to the east and the west of the study area. The Old Orange Line began as an elevated rail in Everett. In 1975, the El to Everett was closed and the Orange Line was rerouted to Malden Center, with a stop at Wellington. In 1977, the Orange Line was extended to Oak Grove. This route provided rapid transit for communities north of Boston. The Red Line was extended beyond Harvard to Alewife in 1984, with additional stations at Davis Square and Porter Square.

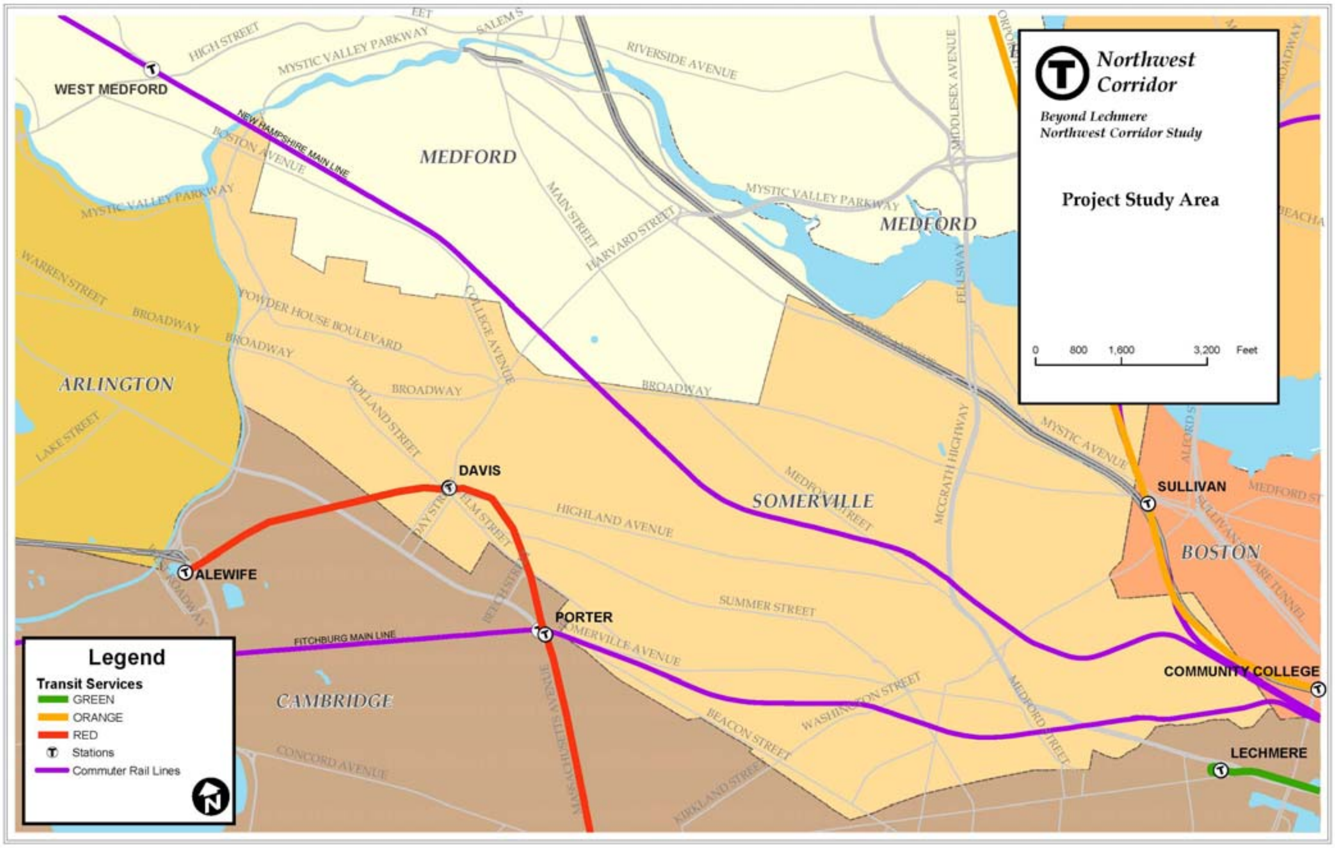
Area commuter rail dates back to 1835 when the New Hampshire Mainline (also known as the Lowell Line) was constructed. In 1841, commuter rail service was established along the Western Route, also known as the Fitchburg Line. Until the late 1800s/early 1900s, on these lines the Boston & Maine Railroad furnished limited commuter rail service at eight stations in Somerville and three stations in Medford. These stations included: Milk Row, Prospect Hill, Winter Hill, Somerville Junction, North Somerville, Somerville (at Park Street), Prospect Street, Union Square, Tufts College, Medford Hillside/Winthrop Street and West Medford.

Today, the Lowell Line and Fitchburg Line continue to operate through the study area. However, commuter rail service can only be accessed at Porter Square via the Fitchburg Line and at West Medford Station via the Lowell Line. On the eastern and western edges of the study area, transit markets are served by the rapid transit lines of the Red and Orange Lines. Stations stops are located on the periphery of the study area via the Red Line at Porter Square in Cambridge and Davis Square in Somerville, and via the Orange Line at Sullivan Square in Boston and Wellington Station in Medford. Although the rapid transit lines border the area, there is no rail service that directly serves the study area.

1.4 Overview of Study Area

The study area for the Beyond Lechmere Northwest Corridor Study is generally bounded by Interstate 93 and the Orange Line to the east, the Red Line and Fitchburg Commuter Rail Line to the west and south, and the West Medford Commuter Rail Station to the north. This area includes East Cambridge, Somerville and portions of Medford (Medford Hillside and West Medford). The area consists of densely settled urban corridors with a large base of commuters and transit users. The study area was defined based on community input as an area that is currently underserved by fixed-guideway transit. Figure 1-1 shows the study area for the Beyond Lechmere Northwest Corridor Study.

Figure 1-1 –Project Study Area



1.5 Relationship to the FTA Planning and Project Development Process

The FTA's process for the planning and development of a project consists of four steps: (1) systems planning; (2) National Environmental Policy Act (NEPA) compliance/alternatives analysis and preliminary engineering (PE); (3) final engineering; and (4) construction. The systems planning and NEPA/PE portion of the process is intended to be carried out as part of the overall metropolitan planning (23 CFR Part 450 FTA/FHWA Joint Final Rule on Metropolitan and Statewide Planning) and environmental review (23 CFR Part 771 Final Rule on Environmental Impact and Related Procedures) processes.

The MIS/AA is the first step of the planning process. The intent of the MIS/AA is to identify and compare the costs, benefits, and impacts of a range of transportation alternatives. FTA views the MIS/AA as a "bridge" between the systems planning process (macro-level metropolitan scale evaluation of regional travel patterns and transportation corridor needs) and preliminary engineering (micro-level design refinement). The MIS/AA is expected to document the full range of alternatives considered consistent with the Purpose and Need of the study.

If a decision is made to pursue Federal Transit Administration (FTA) funding for improvements in the Beyond Lechmere Northwest Corridor study area, the planning process for the project would need to conform to the FTA's planning and project development guidelines. This MIS/AA has been prepared following FTA guidelines for such documents, to maintain eligibility for FTA funding for the project.

1.6 Community Involvement

1.6.1 Advisory Group

To ensure that local concerns and issues were addressed as part of the planning process, an Advisory Group was established to work with the Study Team and meet regularly throughout the study period. The Advisory Group consisted of project stakeholders, including elected officials, businesses, and residents, as well as representatives from the areas of education, environment, labor, social services and transportation. This group represented the various interests of Cambridge, Somerville and Medford; assisted the MBTA in identifying project goals and objectives; provided insight on local concerns and issues; reviewed project documents; and conducted outreach to promote community involvement in project-related meetings.

1.6.2 Public Meetings

The MBTA hosted a series of community meetings in October and November 2004 to update residents on the progress of the study and to receive input on alternatives under consideration. A meeting was held in each community - Cambridge, Somerville and Medford - and was coordinated with city officials. Interpreters were provided at the Cambridge and Somerville meetings for those members of the public requiring such services. An Open House was held prior to each meeting for members of the Study Team to answer questions from the public and for the public to review study materials.

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2

Purpose and Need

This chapter establishes the Purpose and Need for the study and identifies a number of related project goals. The Purpose and Need statement is a simple method for outlining both the reasons for proposing a project and the underlying need for the project.

2.1 Project Purpose

The Purpose of the Beyond Lechmere Northwest Corridor Study is to develop the most appropriate transit strategy for improving mobility and regional access for residents in the northwest corridor communities of Cambridge, Somerville and Medford. Traffic congestion, mode transfer, and service delays hamper access from the study area to downtown Boston and to employment and services from the study area. The Beyond Lechmere Northwest Corridor Study will define cost-effective transit solutions that will make the regional transit system more accessible within the study corridor. The Purpose of this project is to improve corridor mobility, boost transit ridership, improve regional air quality, ensure equitable distribution of transit services, and support opportunities for smart growth initiatives and sustainable development.

2.2 Need for Transportation Improvements

The Need for the Beyond Lechmere Northwest Corridor Project is demonstrated in five main areas. Within these categories, specific needs for transportation improvements have been identified. They include the need to:

- ☐ Improve transit access and mobility
- ☐ Increase transit capacity
- ☐ Provide air quality benefits
- ☐ Advance sustainable development land use goals
- ☐ Provide improved services to Environmental Justice target communities

The following sections contain discussions of Need in each of these areas.

2.2.1 Transit Access and Mobility

- ❒ Access between the study area and downtown Boston is constrained by the roadway network. Roadway congestion in the study area impacts the reliability of current on-street transit services and results in unreasonable travel times that belie the relatively short distance of inner core trips. The study area neighborhoods are among the most dense in the Boston region and ill–suited for auto-dependent transportation. Improvements to transit services would make public transportation a more compelling travel choice by reducing transit travel times throughout the study area and to downtown Boston.

- ❒ The City of Boston continues to provide employment opportunities at all income levels and also contains a substantial employment labor force. Access to jobs in Boston is constrained by the congested roadways and lack of easy connections to alternative transit modes; for instance, in parts of the study area it is necessary for transit patrons to make multiple transfers to reach jobs in Boston. Growth in auto travel within the corridor and the downtown core is unsustainable given roadway and parking capacities. Also, spurring demand for adequately supplied transit services are regional factors including the high cost of parking and the metropolitan area parking freeze. Residents of the study area would benefit from improved employment access and reduced commuting times as well as reduced commuting costs associated with transit alternatives to auto reliance.

- ❒ Roadway congestion, long travel times and multiple transfer connections also constrain access by study area residents to other important destinations, including private and public colleges and universities, medical facilities and specialties, cultural facilities, and sporting events. The growth of these institutions is also constrained by the limitations of the transportation system. Improved transit services would make economic, educational, medical and recreational opportunities within the study area and the region more accessible to corridor households.

- ❒ Only one of the fifteen bus service routes in the study area meets the MBTA’s current Schedule Adherence Standard on weekdays. Congestion in the corridor contributes to the buses’ inability to meet the current standards for service delivery.

2.2.2 Transit Capacity

- ❒ Transit services that currently operate in the study area provide inadequate links between centers of activity within the corridor communities. The existing bus network generates ongoing customer complaints regarding bus reliability, frequency and overcrowding. The potential to improve the reliability and capacity of the bus network in the study area is severely limited by roadway congestion, narrow street widths, and other physical constraints.

- ❒ The capacity of the MBTA's current transit system is constrained by the need for layover and maintenance facilities, by operational limitations, and by rolling stock supply. Planning for new or enhanced transit services must carefully weigh the current capacity limitations of the existing system and define strategies for most effectively using transit system capacity within parameters of constrained operating and capital investment resources. Increased transit capacity and more efficient utilization of transit resources would result in an ability to accommodate increases in ridership, expanded service frequency and operating efficiencies.

2.2.3 Air Quality

- ❒ The study area is located within an area designated non-attainment for ozone by the US Environmental Protection Agency (EPA), with a classification of "serious". Motor vehicles are the predominant sources of ozone precursor emissions within the study area. These emissions are exacerbated by truck traffic through the area. Reducing auto VMT and cutting consequent emissions of volatile organic compounds and carbon monoxide compels the need to improve transit options and promote a shift in travel mode from automobiles.

- ❒ Community concerns related to the rate of chronic diseases in the study area have been expressed at several public meetings. Data gathered from the Massachusetts Department of Public Health's (DPH) Mass Community Health Information Profile (MassCHIP) for Cambridge, Medford, and Somerville shows that the rates of cancer death, asthma, and obstructive pulmonary diseases exceed targets in Cambridge, Medford and Somerville. Improvements to air quality within the study area could potentially have a positive impact on the chronic disease rates.

2.2.4 Sustainable Development/Smart Growth

- ❒ Development in the study area is constrained by traffic congestion, a lack of parking and poor access. Local land use/zoning policies encourage and make allowances for developments in close proximity to transit or public parking facilities. Opportunities for economic development around transit centers are possible within the study area. Introduction of enhanced transit, undertaken in coordination with smart-growth based local land use planning, may support

Commonwealth goals in promoting concentrated mixed use development and revitalizing urban centers.

- ❒ There are a number of local development plans or master plans that are being undertaken by the communities in the study area. The focus of these efforts is to develop or revitalize neighborhoods. Any transportation investment undertaken by the Commonwealth must be coordinated with local land use policies and regulatory structures that support smart growth aims of expanding the region's housing supply and employment base, concentrating development and protecting environmental resources.

2.2.5 Environmental Justice

The study area for the Beyond Lechmere Northwest Corridor Project consists of a significant number of Environmental Justice (EJ) populations. Alleviating the burden on EJ communities and providing benefits to these populations in terms of air quality, mobility, and access to services and jobs are important purposes served by this project. According to the Boston Metropolitan Planning Organization (MPO), the Need to provide improved services to Environmental Justice (EJ) populations that are applicable to this study is demonstrated by[1]:

- ❒ Commuter rail lines pass through the community without providing access to their service.
- ❒ Congestion exists on local streets, particularly on Route 28.
- ❒ There is a need for additional services, such as radial bus connections to employment centers.
- ❒ More off-peak bus service is needed.

2.3 Goals and Objectives

The Beyond Lechmere Northwest Corridor Study is part of a comprehensive effort to achieve a series of broad area transportation goals, as well as specific objectives for improving the quality of transportation services and equitable distribution of services within the study area. The goals, associated objectives, and potential evaluation measures are identified as follows:

2.3.1 Improve Regional Mobility

Mobility improvements in the study area should result in significant improvements in the ability to move people through the study area and to downtown Boston. Improvements should increase accessibility for all users, including residents, employees, students, visitors, and shoppers. Residents of the study area would benefit from improved employment access and reduced commuting times, as well as in reduced travel times and costs. Additionally, improvements to the capacity, reliability and quality of the regional transit system will benefit the existing users of the system. Measures that will be helpful in evaluating the improved transit access and regional mobility include:

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[1] Regional Transportation Plan 2004-2025 of the Boston Region MPO

- The addition of seat-miles and vehicle-hours of service
- Reliability of the service in the study area
- User benefits including travel time savings
- Reductions in the number of transfers required
- Congestion relief
- User costs/fare structure

2.3.2 Expand Transit Access and Intermodal Connections

Expanding the viability of multiple mode choice options will improve efficiency and effectiveness of the region's transportation system. Multimodal connections in the study area between commuter rail, bus services and rapid transit or light rail would also benefit commuters by improving mobility and flexibility in route choice. Factors to be used in evaluating the effectiveness of increased mode choice options include:

- Mode shift
- Transit ridership
- Transit system capacity impacts

2.3.3 Improve Air Quality and Minimize Environmental Impacts

Mobility improvements should contribute to the attainment and long-term maintenance of conformity with National Ambient Air Quality Standards. Mobility improvements should improve overall environmental conditions in the study area and minimize negative impacts. Factors to be considered in evaluating environmental impacts of alternatives include:

- Regional/mesoscale air quality
- Energy consumption
- Vehicular travel/congestion
- Noise
- Vibration
- Historical/archeological
- Section 4(f)/parklands
- Wetlands
- Hazardous materials

2.3.4 Provide Services to Environmental Justice Populations

Improvements to transit services will need to be in conformance with EJ plans to provide benefits to these populations in terms of air quality, mobility, and access to services and jobs. Mobility improvements should conform to the federal, state and local requirements that are intended to promote nondiscrimination in programs affecting human health and the environment. Factors to be used in evaluating the effectiveness of providing services to EJ populations include:

- ☐ Service to EJ target areas
- ☐ Access to opportunities for residents of EJ target areas
- ☐ Improvement in mobility and connectivity and/or removal of barriers faced by EJ areas
- ☐ Relationship of benefits to burdens in EJ areas
- ☐ User benefits including travel time savings

2.3.5 Advance Sustainable Development/Smart Growth Principles

Proposed transportation improvements must advance the State Smart Growth Principles for sustainable development. While transportation improvements alone will not necessarily stimulate economic growth, congestion and the lack of access can be major impediments to implementing a community’s smart growth vision of balanced housing, economic development and open space recreation. The principles guiding the state’s land use and infrastructure investment initiatives are:

1. **Redevelop first.** Support the revitalization of town centers and neighborhoods. Encourage reuse and rehabilitation of existing infrastructure rather than the construction of new infrastructure in undeveloped areas. Give preference to redevelopment of brownfields, preservation and reuse of historic structures and rehabilitation of existing housing and schools.
2. **Concentrate development.** Support development that is compact, conserves land, integrates uses, and fosters a sense of place. Create walkable districts mixing commercial, civic, cultural, educational and recreational activities with open space and housing for diverse communities.
3. **Be fair.** Promote equitable sharing of the benefits and burdens of development. Provide technical and strategic support for inclusive community planning to ensure social, economic, and environmental justice. Make regulatory and permitting processes for development clear, transparent, cost-effective, and oriented to encourage smart growth and regional equity.
4. **Restore and enhance the environment.** Expand land and water conservation. Protect and restore environmentally sensitive lands, natural resources, wildlife habitats, and cultural and historic landscapes. Increase the quantity, quality and accessibility of open space. Preserve critical habitat and bio-diversity. Promote developments that respect and enhance the state’s natural resources.
5. **Conserve natural resources.** Increase our supply of renewable energy and reduce waste of water, energy and materials. Lead by example and

support conservation strategies, clean power and innovative industries. Construct and promote buildings and infrastructure that use land, energy, water and materials efficiently.

6. **Expand housing opportunities.** Support the construction and rehabilitation of housing to meet the needs of people of all abilities, income levels and household types. Coordinate the provision of housing with the location of jobs, transit and services. Foster the development of housing, particularly multifamily, that is compatible with a community's character and vision.
7. **Provide transportation choice.** Increase access to transportation options, in all communities, including land and water based public transit, bicycling, and walking. Invest strategically in transportation infrastructure to encourage smart growth. Locate new development where a variety of transportation modes can be made available.
8. **Increase job opportunities.** Attract businesses to locations near housing, infrastructure, water, and transportation options. Expand access to educational and entrepreneurial opportunities. Support the growth of new and existing local businesses.
9. **Foster sustainable businesses.** Strengthen sustainable natural resource-based businesses, including agriculture, forestry and fisheries. Strengthen sustainable businesses. Support economic development in industry clusters consistent with regional and local character. Maintain reliable and affordable energy sources and reduce dependence on imported fossil fuels.
10. **Plan regionally.** Support the development and implementation of local and regional plans that have broad public support and are consistent with these principles. Foster development projects, land and water conservation, transportation and housing that have a regional or multi-community benefit. Consider the long-term costs and benefits to the larger commonwealth.

2.3.6 Maximize Transportation Efficiencies

Given the transportation need in the study area and the limited funding resources at all levels, the identified mobility improvements should be cost effective and provide mobility benefits. Strategies for implementation of these improvements should conceive new and creative ways to both fund and deliver project elements. Factors to be used in evaluating this goal include:

- ☐ Total capital cost
- ☐ Annual operating and maintenance costs
- ☐ FTA cost effectiveness index

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3

Existing Conditions

This chapter provides information on the existing conditions of the study area neighborhoods in East Cambridge, Somerville, Medford Hillside, and West Medford. It includes information on demographics, travel behavior, roadways and congestion management areas, development patterns and study area projects.

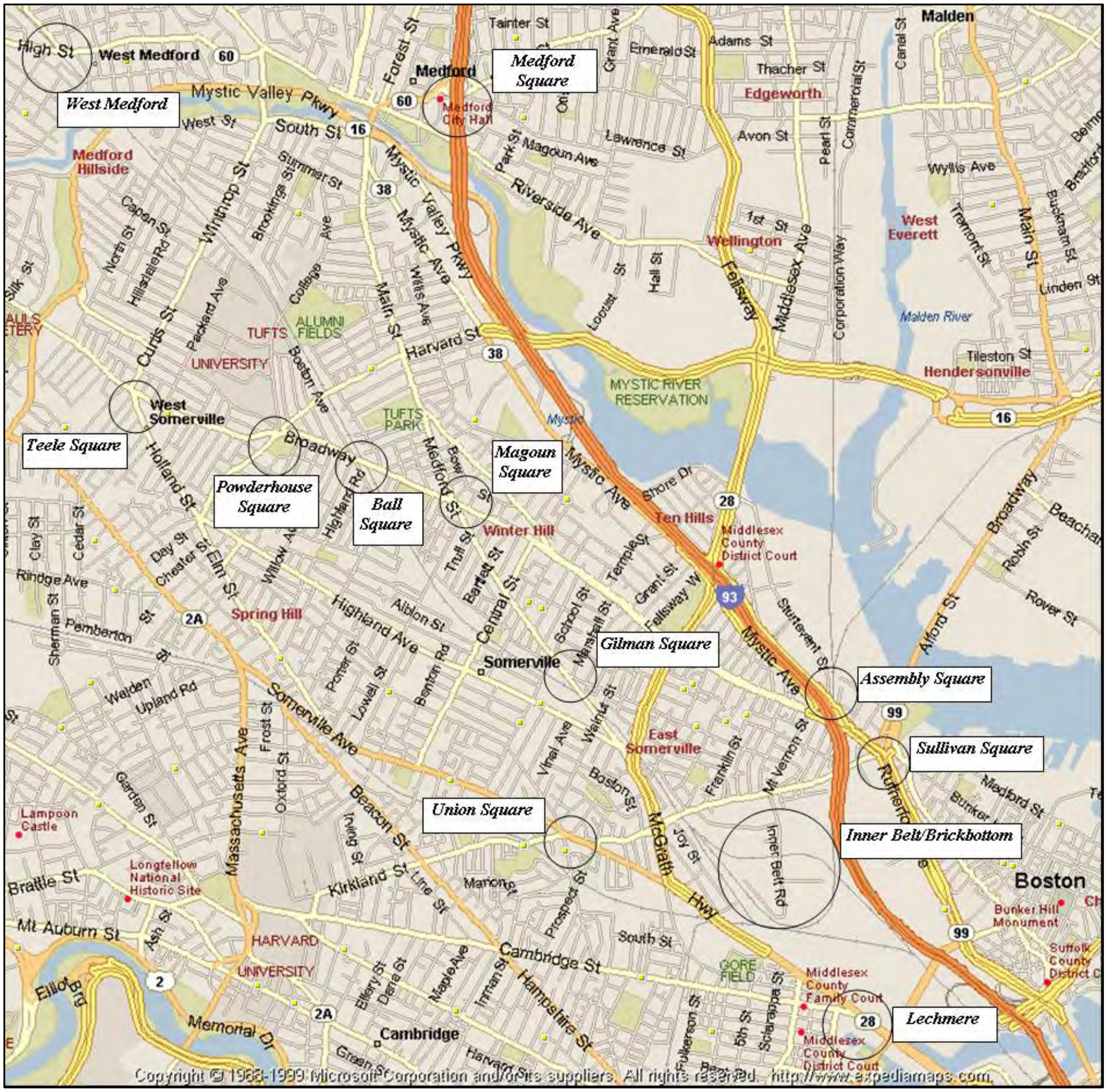
3.1 Description of Study Area

The study area for the Beyond Lechmere Northwest Corridor Study is bounded by Interstate 93 and the Orange Line to the east, the Somerville/Cambridge Line to the west, Lechmere Station on the south and the West Medford Commuter Rail Station to the north. Many of the neighborhoods in East Cambridge, Somerville, and Medford Hillside, and West Medford are focused on neighborhoods or "squares", where commercial activity serving surrounding residential areas is concentrated. Residents often walk to and from these commercial areas to meet their daily commerce needs. Neighborhoods and squares within the study area include:

- Lechmere
- Inner Belt/Brickbottom
- Union Square
- Gilman Square
- Magoun Square
- Ball Square
- Powderhouse Square
- Medford Hillside/Tufts
- Teele Square
- West Medford

Figure 3-1 shows the locations of neighborhoods and squares within the study area.

Figure 3-1 – Study Area Neighborhoods and Squares



3.2 Overview of Transportation Facilities and Service in Corridor

Travel in the study area is oriented towards downtown Boston and neighboring urban centers. On the southern end of the study area, transit markets are served by the Green Line Light Rail Transit service at Lechmere Station. On the eastern and western edges of the study area, transit markets are served by rapid transit facilities (Red and Orange Lines). The Red Line also serves intermediate stations at Porter Square in Cambridge and Davis Square in Somerville. Within the study area, local buses provide connections to the Red, Orange and Green Lines.

The MBTA operates fifteen bus routes that serve the study area. Fourteen of the fifteen services require passengers destined to/from Boston employment centers to transfer at least once during their trip. The quality of the existing bus service in the study area generally meets the MBTA's Service Delivery Policy for loading. However, schedule adherence is a problem in the study area, as only one route, the Route 85, meets the Service Delivery Policy's standards for schedule adherence. This is a typical problem for surface bus routes in areas with traffic congestion as is found in Union Square, Davis Square, Medford Hillside and West Medford Square, among other locations in the project area. The traffic congestion at these locations often leads to service delays on the entire route.

Commuter rail service in the study area is provided in West Medford via the MBTA's Lowell Line, also known as the New Hampshire Main Line. There are no commuter rail stops in Somerville on the Lowell Line. Commuter rail service is provided on the western edge of the study area via the MBTA's Fitchburg Commuter Rail Line at Porter Square. Guilford Rail System (GRS) operates freight service over both the Fitchburg and Lowell Lines. The community of Somerville has voiced concerns that there are four transit rail lines (two commuter rail and two rapid transit lines) running through the city with one subway stop at the western periphery and no commuter rail stops. The community of Medford has expressed concerns about the physical condition of West Medford Station.

3.3 Source Documents

In compiling the information provided in this document a number of sources were utilized. The following is a brief summary of the source documents:

- Assembly Square Mixed-Use District, City of Somerville Office of Housing and Community Development , 2004
- Beyond Lechmere Alternatives Evaluation Report, MBTA/Lane, Frenchman, and Associates/Fay Spofford and Thorndike, Inc., 1984
- Boston Region MPO: Regional Transportation Plan 2004-2025, Boston Metropolitan Planning Organization Region, 2003
- Changes to Service Delivery Policy, Massachusetts Bay Transportation Authority, Adopted December 2002.
- Circumferential Transportation Improvements in the Urban Ring Corridor - Expanded Environmental Notification Form (ENF), Earth Tech, 2001
- Circumferential Transportation Improvements in the Urban Ring Corridor - Phase Two Draft Environmental Impact Report/Statement (DEIR/S) Scoping Summary Report, EarthTech, 2001

- Evaluation of Transit Alternatives Beyond Lechmere Station, MBTA, 1981
- Inner Belt Planning Study - Technical Memorandum I: Existing Conditions, City of Somerville Office of Housing and Community Development, 2001
- Load Profiles, MBTA Comprehensive Ridecheck Program, Winter 1997/1998 through Winter 2003.
- MassHighway Accident Database, 1998 - 2002
- MassHighway 2002 Traffic Volume Database
- MBTA Bus and Train Service Schedules, www.mbta.com, June 2004.
- MBTA Commuter Rail Train Audit, Massachusetts Bay Commuter Railroad Company, December 2003.
- MBTA Reverse Commuting Study, Central Transportation Planning Staff, 2001.
- McGrath Highway Corridor - Technical Memorandum 1: Existing Conditions, City of Somerville Office of Housing and Community Development, 2002
- North Point Somerville - Planning Study, ICON Architects/FMX Associates/Bruce Campbell and Associates/City of Somerville Office of Housing and Community Development, 2003
- Preliminary 2004 Service Plan: Proposed Bus Service and Service Policy Modifications, Massachusetts Bay Transportation Authority, 2004.
- Ridership and Service Statistics, Eighth Edition, Massachusetts Bay Transportation Authority, 2001.
- Service Delivery Policy, Massachusetts Bay Transportation Authority, Sept., 1996
- Somerville Community Path Feasibility Study, Rizzo Associates/ICON Architecture, 2001
- Streetcar Lines of the Hub, Clarke, Bradley H., Boston Street Railway Association, 2004
- Streetcar Suburbs, Warner, Samuel, Harvard University Press, 1962
- Transportation Element for the Somerville Community Development Plan: Crashes 1995-1999, Central Transportation Planning Staff.
- Truck Traffic Study in the City of Somerville for the Department of Traffic & Parking, Bayside Engineering, 2001
- Union Square Master Plan, Bluestone Planning Group, 2003
- Union Square Transportation Plan, Executive Summary City of Somerville Office of Housing and Community Development/Edwards and Kelcey

3.4 Demographics and Travel Behavior

Data from the 1990 and 2000 U.S. Census were reviewed to identify population, employment, and travel behavior within the study area. These characteristics are summarized in the following sections.

3.4.1 Population

According to the U.S. Census, the 2000 population in the study area communities at the municipality level were: 55,765 in Medford; 101,355 in Cambridge; and 77,478 in Somerville. The study area has been further broken down to reflect the individual census tracts for the purpose of summarizing demographics and travel behavior. Figure 3-2 delineates the census tracts included within the study area.

Figure 3-2 – Study Area Census Tracts

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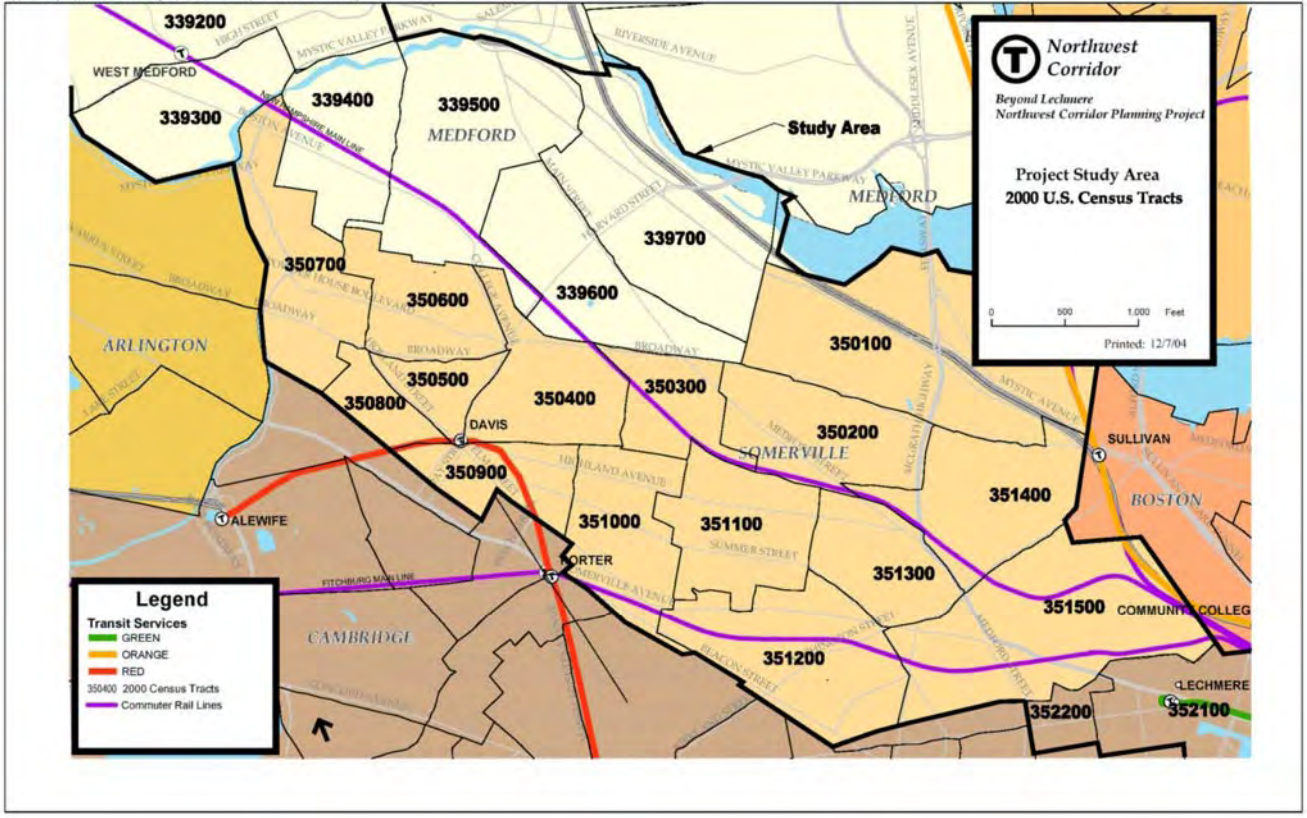


Table 3-1 shows the relationship between population, land area and population density for the census tracts contained within the study area. Median age, housing values and household income are also provided.

Table 3-1 – Population and Demographics by Census Tract

By Census Tract	Total Population	Land Area (square miles)	Population Density (population/ square mile)	Median Age	Median Housing Values	Median Household Income
Medford Tracts						
Tract 3392	5,883	1.0	5,794	41.9	$280,800	$71,295
Tract 3393	3,017	0.3	11,189	38.6	$194,000	$51,352
Tract 3394	3,512	0.2	14,396	33.8	$238,100	$48,607
Tract 3395	5,702	0.5	12,112	25.6	$230,500	$56,477
Tract 3396	5,042	0.3	15,842	34.5	$249,200	$51,681
Tract 3397	4,039	0.5	8,632	35.9	$230,300	$45,149
Somerville Tracts						
Tract 3501	8,964	0.7	12,934	31	$244,600	$40,436
Tract 3502	6,806	0.3	25,208	33	$244,800	$45,326
Tract 3503	2,457	0.2	16,213	33.2	$191,500	$46,610
Tract 3504	5,921	0.2	25,128	30.9	$313,900	$56,643
Tract 3505	1,639	0.1	18,572	31.3	$340,400	$60,700
Tract 3506	4,665	0.2	23,390	22.1	$332,000	$56,094
Tract 3507	6,096	0.3	19,398	31.2	$313,100	$44,766
Tract 3508	1,743	0.1	21,222	30.3	$311,900	$54,457
Tract 3509	3,106	0.2	20,331	30.6	$339,600	$54,799
Tract 3510	6,395	0.3	25,064	29.5	$277,800	$53,563
Tract 3511	5,932	0.3	22,622	32.9	$251,500	$50,465
Tract 3512	8,451	0.4	22,329	29.8	$231,700	$48,452
Tract 3513	4,336	0.2	22,196	33.7	$260,200	$33,516
Tract 3514	8,881	0.3	28,860	31	$219,700	$36,113
Tract 3515	2,086	0.5	3,982	34.4	$167,200	$36,516
Cambridge Tracts						
Tract 3521	3,079	0.3	9,910	31.8	$356,100	$48,529
Tract 3522	1,974	0.1	32,950	35.6	$205,400	$23,750
Overall Study Area	**109,726**	**7.3**	**15,100**			

Sources: Data from 2000 United States Census

3.4.2 Population and Health

On the following page, Table 3-2 summarizes data gathered from the Massachusetts Department of Public Health's (DPH) Mass Community Health Information Profile (MassCHIP) for Cambridge, Medford, and Somerville, as well as statewide. Also included in the table are key chronic disease objectives (target rates) set forth by DPH. Each community's current rate can be compared to the target rate.

Table 3-2 – Population and Health Status Indicators

	Statewide	Cambridge	Medford	Somerville
Demographic Indicators*				
Per Capita Income	$25,952	$31,156	$24,707	$23,628
Population below 100% of poverty level (%)	9.3	12.9	6.4	12.5
Population below 200% of poverty level (%)	21.7	27.8	18.7	26.6
Children less than 18 years of age living below 100% of poverty line (%)	12.0	15.6	6.1	15.2
Unemployed Person age 16 and older (%)	5.3	3.8	4.6	4.5
White non-Hispanic persons (%)	83.9	67.9	87.2	77.7
Black non-Hispanic persons (%)	5.3	12.1	6.2	6.6
Hispanic persons (%)	6.8	7.4	2.6	8.8
Asian persons (%)	3.9	12.4	4.0	6.8

		Actual			
	Target Age-adjusted Rate**	**Statewide Age-adjusted Rate****	**Cambridge Age-adjusted Rate****	**Medford Age-adjusted Rate****	**Somerville Age-adjusted Rate****
Chronic Disease Indicators					
Total cancer deaths	------	202.4	186.4	215.4	233.9
Cardiovascular disease deaths	-----	284.2	270.8	259.3	253.5
Hospital Discharges for Primary Care Manageable Conditions					
Asthma	-----	130.8	123.1	126.6	137.7
Chronic Disease Objectives					
Reduce the overall cancer death rate. (All types of cancer)	44.9	202.4	186.4	215.4	233.9
Reduce asthma deaths - under 5 years of age. ***	0.1	0.3	0.0	0.0	0.0
Reduce asthma deaths - ages 5 to 14 years.***	0.1	0.4	0.0	0.0	0.0
Reduce asthma deaths - ages 15 to 34 years.***	0.2	0.5	2.1	0.0	0.0
Reduce asthma deaths - ages 35 to 64 years.***	0.9	1.3	6.3	4.9	0.0
Reduce asthma deaths - ages 65 years or older.***	6.0	4.5	10.8	0.0	0.0
Reduce hospitalizations for asthma - under 5 years of age.****	250.0	346.1	290.3	404.7	400.7
Reduce hospitalizations for asthma - age 5 to 64 years.****	77.0	105.6	71.8	87.7	88.0
Reduce hospitalizations for asthma - 65 years and older.****	110.0	173.6	162.8	165.6	233.3
Chronic obstructive pulmonary diseases - ages 45 years and older.	60.0	121.7	95.3	116.5	116.1

Notes:

*2000 Census Counts or Sampling Data - most recent population estimates

Denominator for persons age less than 18 and living in poverty is all persons age less than 18.
Unemployment rate: all unemployed persons in labor force divided by all persons in labor force.
AFDC recipients percent denominator is persons age less than 65 (eligible population based on age)
Multiple Assistance Unit recipients percent denominator is persons less than age 25 (eligible population based on age)

**Age adjusted rates: A procedure for adjusting rates, designed to minimize the effects of age differences in age distributions when comparing rates for different populations. Age-adjusted rates are expressed per 100, 000 persons. For standardization within Mass Community Health Information Profile (MassCHIP) the standard population used is the 2000 US population.

***Objective has been reworded, but it maintains its meaning. Objectives seek a rate of death per 1.0 million. The modified definition converts the rate of deaths per 100,000.

****MassCHIP can only approximately measure the objective. Hospital discharges data set does not include emergency room visits, where many cases of asthma are seen. Objectives have been reworded, but maintain the same meaning. The objectives seek a rate of hospitalizations per 10,000. The modified definition converts the rate to deaths per 100,000.

3.4.3 Population and Employment

Table 3-3 shows the relationship between population and employment for the cities that will be served by improved transit in the study area. Journey to work information for 2000 currently is only available at the municipality level. Based on journey to work information, a resident to job ratio by municipality is shown to give an indication of whether the city is a net importer or exporter of workers. These data consider only the existing flows of commuters between the cities.

Table 3-3 – Population and Employment

	Municipality of Residence			
Category	**Cambridge**	**Medford**	**Somerville**	**Boston**
Population*	101,355	55,765	77,478	589,141
Employment**	113,500	19,000	23,000	578,500
Resident to Job Ratio	0.89	2.93	3.37	1.02

Sources:
* Data from 2000 Census Minor Civil Division (MCD) Journey to Work Tables
** Data from the Mass Division of Employment and Training (DET) for 2001

From this table, the following is indicated:

- Boston and Cambridge are regional job centers. Both cities nearly double their population in the daytime because of job supply.
- Somerville and Medford have populations about three times greater than their job supply.

3.4.4 Travel Behavior for Residents

Table 3-4 presents the travel characteristics of residents at the municipality level. This information was obtained from 2000 Census Minor Civil Division (MCD) Journey to Work Tables.

Table 3-4 – Commute Travel Behavior for Residents

	Municipality of Residence			
Category	**Cambridge**	**Medford**	**Somerville**	**Boston**
Population*	101,355	55,765	77,478	589,141
Percent of Resident Labor Force Working in Cambridge*	46 %	11 %	20 %	6 %
Percent of Resident Labor Force Working in Medford*	1 %	17 %	4 %	0 %
Percent of Resident Labor Force Working in Somerville*	2 %	5 %	16 %	1 %
Percent of Resident Labor Force Working in Boston*	27 %	25 %	28 %	66 %
Percent of Residents who Work in Study Area	76 %	58 %	68 %	73 %
Percent of Residents who Work Beyond the Study Area	24 %	42 %	32 %	27 %

Sources:
* Data from 2000 Census Minor Civil Division (MCD) Journey to Work Tables

Table 3-4 indicates the following travel behaviors for residents in the study area, based on municipality level data:

- **Medford** - Medford has the highest proportion of people who work outside the study area (42%). Within the study area, the largest concentration of employment for Medford residents is in Boston (28%). A modest number of Medford residents also work in Medford (17%) and in Cambridge (11%). The smallest work location percentage for Medford residents is Somerville (5%).
- **Somerville -** A large portion of Somerville residents work in Cambridge (20%) and Boston (28%). Interestingly, Somerville has the smallest percentage of residents who work in their city of residence (16%). A small percentage of Somerville residents work in Medford (4%).
- **Cambridge** – 46% of Cambridge residents also work in Cambridge, while a small portion of Cambridge residents work in Medford (1%) or Somerville (2%). Overall, 76% of Cambridge residents work within the study area.
- **Boston** - Data shows that a relatively small portion of Boston residents commute to Medford and Somerville (1%). Employment for Boston residents is concentrated in Boston; although, a moderate portion of Boston residents commute to Cambridge (6%).

3.4.5 Travel Behavior for Workers

The previous section evaluated the work commute travel behavior of residents in the study area. This section provides an employment-based perspective of travel patterns. The data indicate how each municipality functions in the Boston metropolitan regional economy. Table 3-5 presents the travel characteristics of workers employed in each of the municipalities.

Table 3-5 –Travel Behavior Data for Workers

	Municipality of Workplace			
Category	**Cambridge**	**Medford**	**Somerville**	**Boston**
Employment**	113,500	19,000	23,000	578,500
Percent of Workers who Live in Cambridge*	22 %	2 %	6 %	3 %
Percent of Workers who Live in Medford*	3 %	25 %	6 %	1 %
Percent of Workers who Live in Somerville*	8 %	8 %	31 %	2 %
Percent of Workers who Live in Boston*	14 %	7 %	9 %	36 %
Percent of Workers who Live in the Study Area	47 %	42 %	52 %	42 %
Percent of Workers who Live Beyond Study Area	53 %	58 %	48 %	58 %

Sources:
* Data from 2000 Census Minor Civil Division (MCD) Journey to Work Tables
** Data from the Mass Division of Employment and Training (DET) for 2001

Table 3-6 presents the travel mode to work of employed residents within the study area, based on 2000 U.S. Census Tract data. As shown in this table, 27% of employed residents take public transportation to work in the study area census tracts. Forty-nine percent of employed residents drive alone to their jobs, and 10% of employed residents reported carpooling as their means of transportation to work.

Table 3-6 –Travel Modes to Work by Census Tract

Census Tracts	**Mode of Transportation to Work**											
	Drive alone		**Carpool**		**Public Transportation**		**Bicycle**		**Walk**		**Other/ Work at Home**	
	Pop.	**%**	**Pop.**	**%**	**Pop.**	**%**	**Pop.**	**%**	**Pop.**	**%**	**Pop.**	**%**
Medford Tracts												
Tract 3392	2,269	73%	202	6%	531	17%	29	<1%	23	<1%	72	2%
Tract 3393	957	60%	76	5%	465	29%	18	1%	24	2%	50	3%
Tract 3394	1,082	58%	168	9%	396	21%	27	1%	155	8%	28	2%
Tract 3395	1,508	54%	183	7%	515	18%	5	<1%	500	18%	90	3%
Tract 3396	1,924	66%	231	8%	586	20%	14	<1%	76	3%	70	2%
Tract 3397	1,154	55%	410	20%	397	19%	25	1%	72	3%	29	1%
Subtotal	**8,894**		**1,270**		**2,890**		**118**		**850**		**339**	
Average		**62%**		**9%**		**20%**		**<1%**		**6%**		**2%**
Somerville Tracts												
Tract 3501	2,201	51%	855	20%	904	21%	29	<1%	246	6%	61	1%
Tract 3502	2,061	53%	594	15%	922	24%	63	2%	162	4%	118	3%
Tract 3503	805	56%	125	9%	358	25%	62	4%	47	3%	50	3%
Tract 3504	1,620	44%	234	6%	1,365	37%	48	1%	263	7%	153	4%
Tract 3505	482	43%	26	2%	505	45%	13	1%	74	7%	34	3%
Tract 3506	942	37%	139	5%	605	24%	63	2%	701	27%	108	4%
Tract 3507	1,870	53%	195	6%	1,054	30%	25	<1%	259	7%	123	3%
Tract 3508	475	42%	66	6%	513	45%	19	2%	36	3%	24	2%
Tract 3509	840	37%	97	4%	1,033	46%	50	2%	174	8%	66	3%
Tract 3510	1,793	41%	255	6%	1,635	37%	202	5%	458	10%	70	2%
Tract 3511	1,822	51%	278	8%	915	26%	125	4%	308	9%	123	3%
Tract 3512	1,833	35%	556	11%	1,278	25%	372	7%	921	18%	205	4%
Tract 3513	1,096	46%	279	12%	621	26%	80	3%	232	10%	69	3%
Tract 3514	2,095	47%	756	17%	1,175	27%	59	1%	234	5%	108	2%
Tract 3515	428	40%	193	18%	246	23%	41	4%	131	12%	28	3%
Subtotal	**20,363**		**4,648**		**13,129**		**1,251**		**4,246**		**1.340**	
Average		**45%**		**10%**		**29%**		**3%**		**9%**		**3%**
Cambridge Tracts												
Tract 3521	593	39%	105	7%	380	25%	23	2%	314	21%	89	6%
Tract 3522	317	35%	62	7%	229	25%	21	2%	269	30%	11	1%
Subtotal	**910**		**167**		**609**		**44**		**583**		**100**	
Average		**38%**		**7%**		**25%**		**2%**		**24%**		**4%**
Overall Total	**30,167**		**6,085**		**16,628**		**1,413**		**5,679**		**1,779**	
Study Area Average		**49%**		**10%**		**27%**		**2%**		**9%**		**3%**

Note:
The Other/Work at Home category includes the U.S. Census Bureau categories Other, Motorcycle, and Work at Home.

Table 3-7 summarizes the auto availability by census tract within the study area. As shown in this table, 21% of the households within the study area do not own a vehicle.

Table 3-7 –Auto Availability by Census Tract

	Occupied Housing Units	Occupied Housing Units with No Vehicle Available	% of Occupied Housing Units with No Vehicle Available
Medford Tracts			
Tract 3392	2,196	135	6%
Tract 3393	1,248	197	16%
Tract 3394	1,500	296	20%
Tract 3395	1,631	161	10%
Tract 3396	2,097	311	15%
Tract 3397	1,603	189	12%
Subtotal	**10,275**	**1,289**	
Average			**13%**
Somerville Tracts			
Tract 3501	3,343	745	22%
Tract 3502	2,653	525	20%
Tract 3503	1,020	166	16%
Tract 3504	2,522	348	14%
Tract 3505	734	141	19%
Tract 3506	1,090	123	11%
Tract 3507	2,783	811	29%
Tract 3508	768	148	19%
Tract 3509	1,492	286	19%
Tract 3510	2,964	570	19%
Tract 3511	2,539	536	21%
Tract 3512	3,579	1,009	28%
Tract 3513	2,006	677	34%
Tract 3514	3,111	779	25%
Tract 3515	951	310	33%
Subtotal	**31,555**	**7,174**	
Average			**23%**
Cambridge Tracts			
Tract 3521	1,524	397	26%
Tract 3522	1,124	547	49%
Subtotal	**2,648**	**944**	
Average			**36%**
Overall Total	**44,478**	**9,407**	
Study Area Average			**21%**

Table 3-8 demonstrates the average times it takes for residents to travel to work. The travel times are based on the number of workers over the age of 16 in each census tract and broken down into the mode by which they travel either using public transportation or other means. The percentage of workers and the time it takes to travel to work were calculated for each community, and for the overall study area using this 2000 U.S. Census data.

Tables 3-5, 3-6 3-7, and 3-8 indicate the following travel behaviors for workers in the study area:

- ❐ **Medford** – Almost six out of ten employment positions in Medford are held by people commuting from outside the study area communities. One-quarter of Medford's labor force lives and works in Medford. A modest number of Medford workers live in Somerville (8%) and in Boston (7%). In terms of work commute mode choice, Medford residents within the study area have the highest reliance on the automobile for commuting trips (62%) and the lowest walk/bike (7%) and transit (20%) mode shares. For those who take public transportation, travel times to work between 30 and 44 minutes are the most common. The most common travel time to work for those commuting by means other than public transportation is less than 30 minutes.
- ❐ **Somerville –** One-third of Somerville's employment base consists of jobs filled by Somerville residents. In terms of work commute mode choice in the study area census tracts, Somerville residents rely more heavily (29%) on public transit than their counterparts in Cambridge (25%) or Medford (20%). The most popular commuting mode for Somerville residents is the single-occupant automobile, which accounts for 45% of trips. Together, walking and bicycling are the travel mode choice of 12% of Somerville commuters. For those who take public transportation, travel times to work between 30 and 44 minutes are the most common. The most common travel time to work for those commuting by means other than public transportation is less than 30 minutes.
- ❐ **Cambridge** – A smaller portion of people employed in Cambridge live in the same community (22%) than in any of the other study area communities. Overall, less than half (47 %) of Cambridge workers live in Cambridge, Somerville, Medford or Boston. In terms of work commute mode choice, only 38% of study area Cambridge residents drive to work. Walking and bicycling are important modes, accounting for 26% of commuting trips, which is significantly higher than in other areas. Public transportation carries 25% of commuting trips from the study area. For those who take public transportation and those who take means other than public transportation, the most common travel time to work is less than 30 minutes.

Table 3-8 –Travel Times to Work by Census Tract

	Travel Time to Work											
	Less than 30 minutes			**30 to 44 minutes**			**45 to 59 minutes**			**60 or more minutes**		
Census Tracts	**Total**	**Public Transportation**	**Other Means**	**Total**	**Public Transportation**	**Other Means**	**Total**	**Public Transportation**	**Other Means**	**Total**	**Public Transportation**	**Other Means**
Medford Tracts												
Tract 3392	1694	64	1630	969	244	725	268	149	119	131	74	57
Tract 3393	689	90	599	448	118	330	245	150	95	158	107	51
Tract 3394	897	56	841	604	159	445	219	101	118	108	80	28
Tract 3395	1577	70	1507	799	270	529	226	102	124	135	73	62
Tract 3396	1585	119	1466	795	191	604	244	131	113	217	145	72
Tract 3397	1181	88	1093	564	159	405	206	122	84	113	28	85
Subtotals	7623	487	7136	4179	1141	3038	1408	755	653	862	507	355
% of Total		**4%**	**51%**		**8%**	**22%**		**5%**	**5%**		**4%**	**3%**
Somerville Tracts												
Tract 3501	2369	251	2118	1071	356	715	274	113	161	521	184	337
Tract 3502	1914	150	1764	1272	415	857	381	202	179	257	155	102
Tract 3503	726	56	670	473	185	288	123	69	54	92	48	44
Tract 3504	1659	280	1379	1169	671	498	458	277	181	251	137	114
Tract 3505	617	235	382	332	178	154	104	78	26	61	14	47
Tract 3506	1541	110	1431	573	286	287	256	176	80	96	33	63
Tract 3507	1545	172	1373	1160	480	680	402	214	188	327	188	139
Tract 3508	439	104	335	443	279	164	146	79	67	81	51	30
Tract 3509	1186	386	800	687	420	267	250	191	59	77	36	41
Tract 3510	2210	383	1827	1428	806	622	441	295	146	275	151	124
Tract 3511	1731	206	1525	1089	319	770	390	222	168	251	168	83
Tract 3512	2796	288	2508	1599	609	990	414	284	130	187	97	90
Tract 3513	1116	66	1050	646	226	420	337	199	138	248	130	118
Tract 3514	2531	356	2175	1270	447	823	278	145	133	295	227	68
Tract 3515	607	82	525	325	122	203	54	22	32	53	20	33
Subtotals	22987	3125	19862	13537	5799	7738	4308	2566	1742	3072	1639	1433
% of Total		**7%**	**45%**		**13%**	**18%**		**6%**	**4%**		**4%**	**3%**
Cambridge Tracts												
Tract 3521	949	204	745	370	129	241	52	8	44	81	39	42
Tract 3522	552	98	454	227	90	137	74	33	41	50	8	42
Subtotals	1501	302	1199	597	219	378	126	41	85	131	47	84
% of Total		**13%**	**51%**		**9%**	**16%**		**2%**	**4%**		**2%**	**3.6%**
Overall Total	39734	4401	35333	22492	8300	14192	7250	4117	3133	4927	2700	2227
% of Study Area Total		**6.5%**	**47%**		**12%**	**19%**		**6%**	**4%**		**4%**	**3%**

3.4.6 Environmental Justice

Environmental Justice is an important element of policy making in transportation planning. Environmental Justice efforts focus on improving the environment in under served communities, specifically minority and low-income communities; addressing disproportionate adverse environmental impacts that may exist in those communities; and providing opportunities for racial and ethnic minorities to participate in the decision making process.

The federal government has identified Environmental Justice as an important goal in transportation. Local and regional governments are also incorporating Environmental Justice into transportation programs.

3.4.6.1 EJ Guidelines

The study area for the Beyond Lechmere Northwest Corridor Project includes a number of Environmental Justice (EJ) Populations. The following sections and figures describe the guidelines for Environmental Justice from the federal, state and local perspectives, and depict graphically the EJ populations within the study area.

Federal

Environmental Justice is concerned with the impacts of services and Federal funding on defined minority and low-income populations. The US DOT Order (5610.2) on Environmental Justice defines a disproportionately high effect on minority and low-income populations as: an adverse effect that is predominately borne by minority population and/or a low-income population; or will be suffered by the minority population and/or low-income population and is appreciably more severe or greater in magnitude than the adverse effect that will be suffered by the non-minority population and/or non low-income population.

The data used to analyze EJ compliance are generally based on 2000 U.S. Census data. The “Block Group level” is the smallest geographic area for which income, race, and ethnicity data are available from the U.S. Bureau of the Census. The characteristics of the population within the study area are compared to thresholds established by the state, municipality, or Metropolitan Planning Organization. The analysis identifies minority population, Hispanic population and low-income populations.

State

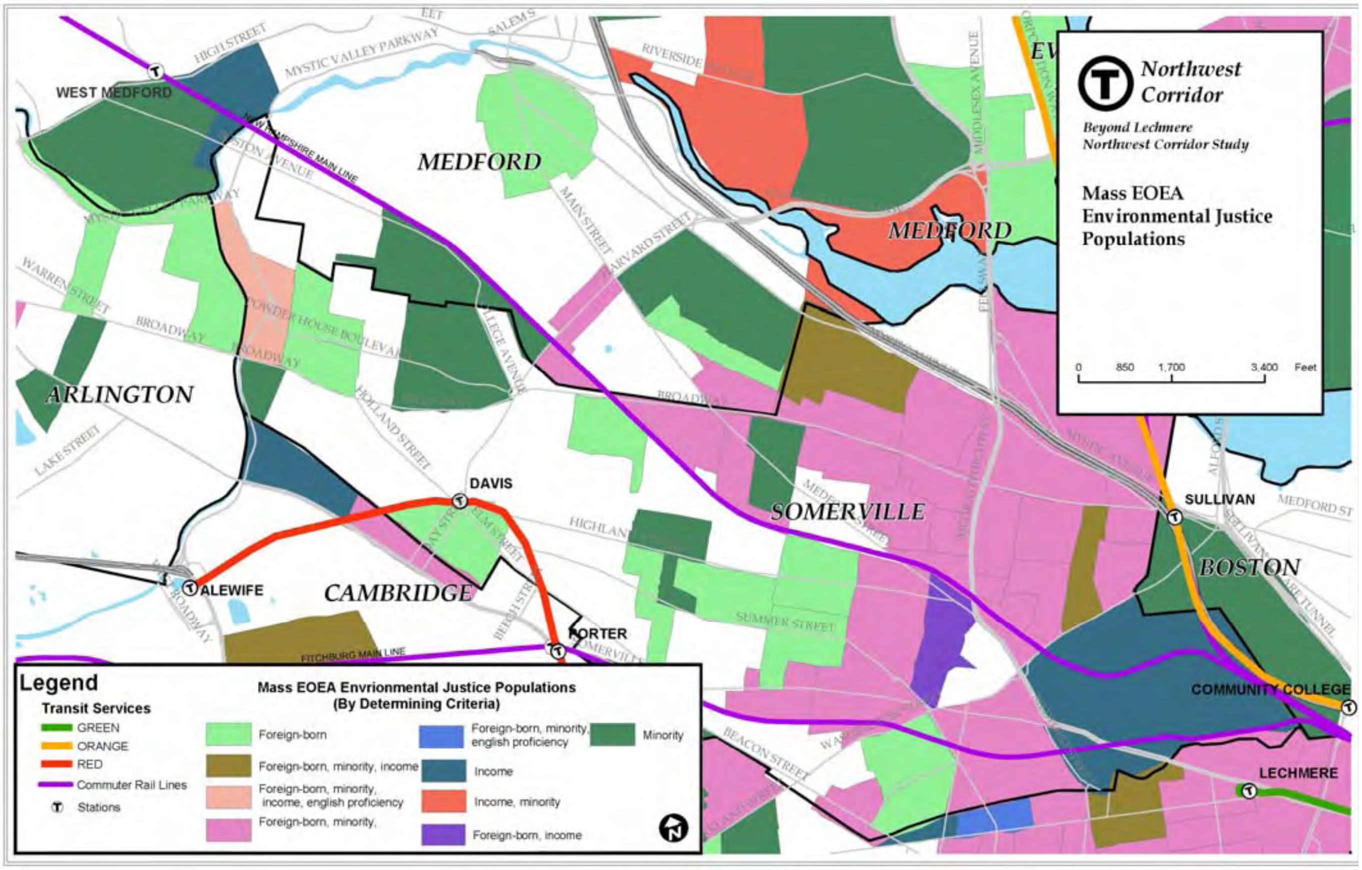
The Environmental Justice Policy of the Executive Office of Environmental Affairs (EOEA) is an effort to protect the environment and public health in the Commonwealth of Massachusetts. EJ is based on the principle that all people have the right to be protected from environmental pollution and to live in and enjoy a clean and healthful environment. EOEA’s EJ Policy makes

Environmental Justice an integral consideration in the implementation of all state environmental programs, including but not limited to, the grant of financial resources, the implementation and enforcement of laws, regulations and policies, and the provision of access to both active and passive open space.

The policy focuses attention on the high-minority/low-income neighborhoods in Massachusetts where residents are likely to be unaware of or unable to participate in environmental decision-making or to gain access to state environmental resources. The policy defines EJ populations as neighborhoods, defined by the US Census Bureau, that meet one of the following criteria: median annual household incomes are at or below 65% of the statewide median; 25% of the residents are minority; 25% of the residents are foreign born; or 25% of the residents are lacking English language proficiency. EJ populations are generally located in densely populated urban neighborhoods. These neighborhoods are generally smaller in area, with larger populations and are located in close proximity to contaminated and abandoned sites and large sources of air emissions. MASSGIS mapping developed by the EOEA is used to determine if an area meets the criteria of an EJ Population.

MASSGIS mapping developed by the EOEA indicates that portions of Cambridge and Medford and a significant area of Somerville include EJ populations. Figure 3-3 indicates those neighborhoods that are categorized as EJ populations according to Massachusetts EOEA guidelines.

Figure 3-3 – Mass. EOEA Environmental Justice Populations



Boston Region MPO

The Boston Region Metropolitan Planning Organizations (MPO), working with the Environmental Justice community, has developed methodologies to assess the impacts of their transportation plans and planning processes on low-income and minority populations. According to the guidelines established, Environmental Justice requires the MPO to:

- Examine the allocation of benefits and burdens, currently and in the planned future,
- Ensure that minority and low-income communities are treated equitably in the provision of transportation services and projects, and
- Provide full participation for minority and low-income communities to advise the MPO during its planning and decision-making process.

Performance measures used by the Boston Region MPO include:

- Mobility and congestion
- Environment
- Access to needed services and jobs

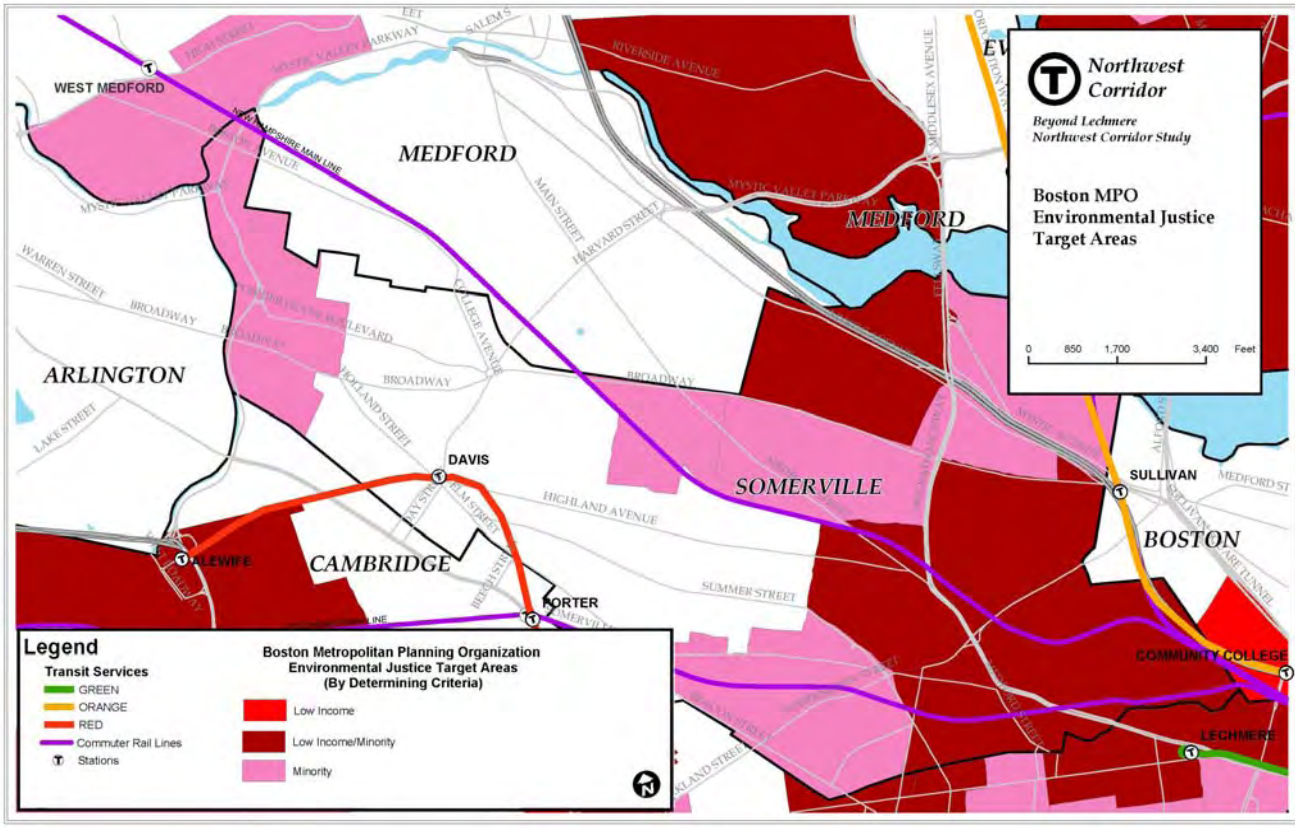
The Boston Region MPO has compiled profiles of the Environmental Justice Communities of Concern as part of the Regional Transportation Plan 2004-2025.

Sections of Cambridge, Somerville and Medford have been identified as populations of concern, or target populations. Target populations are based on traffic analysis zones (TAZs), which is an aggregation of census geography based on population and number of trips. Target populations are defined as:

- Low income – A low-income TAZ was defined as having a median household income at or below 75% of the MPO's median household income in 2000 (≤ $41,850).
- Minority – A minority TAZ was defined as having a percentage of minority population greater than 21.4%.
- Not fluent in English – These TAZs were defined as areas in which over 4.1% of the residents five years and older were unable to speak English fluently.
- Zero-vehicle households – A zero-vehicle household TAZ was defined as an area in which more than 15.4% of all households were without autos.

Several target neighborhoods based on the density of low-income and minority populations residing in them were identified. These target areas are shown in Figure 3-4.

Figure 3-4 – Boston MPO Environmental Justice Target Areas



3.4.6.2 Study Area EJ Communities

It is the goal of this study that improvements to transit services not burden and, to the greatest extent possible, provide benefits to these environmental justice populations in terms of air quality, mobility, and improved regional access. By applying the criteria established by both EOEA and the Boston MPO to the 2000 U.S. Census tract data, Table 3-9 demonstrates how the EJ criteria relate to the study area.

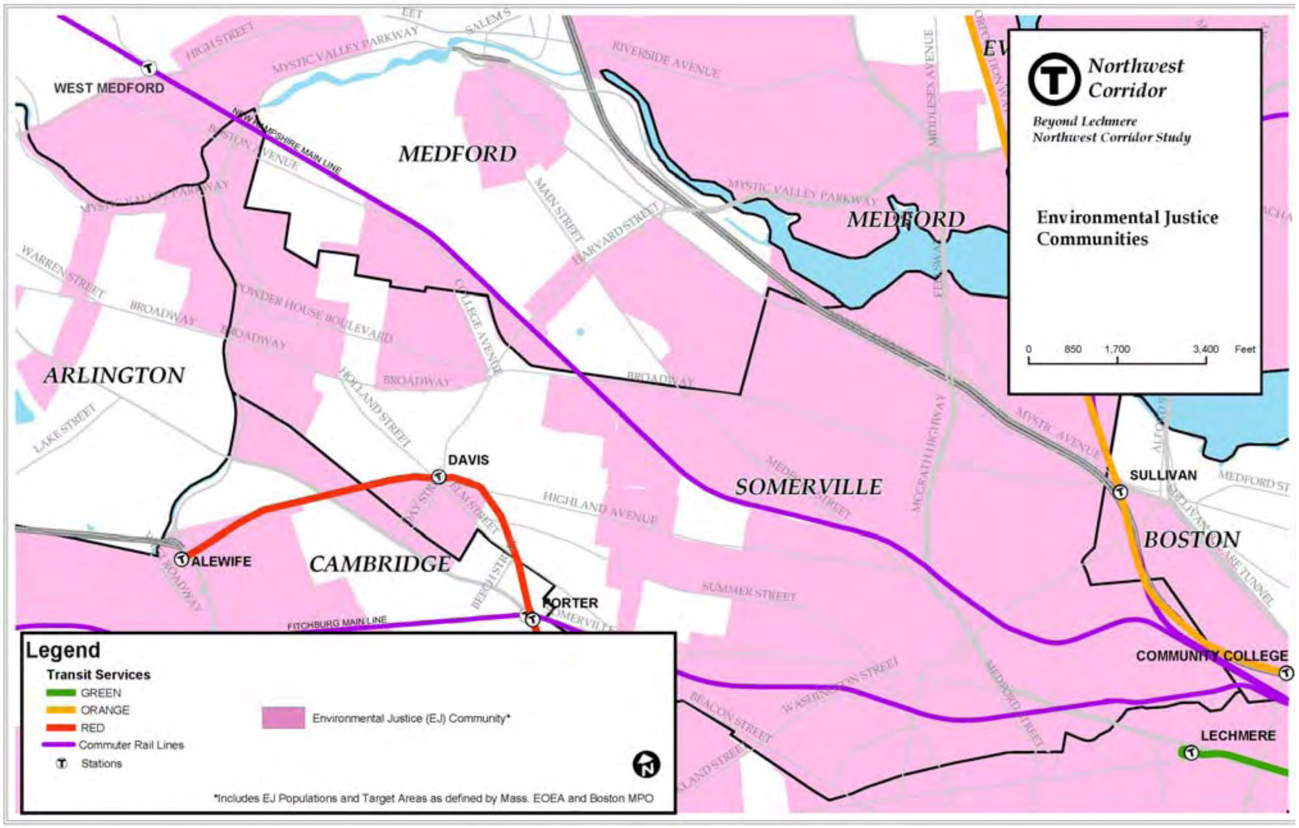
Table 3-9 – Environmental Justice Criteria Applied by Census Tract

Census Tract	Percent Minority Population	Percent Foreign Born Population	Percent of Population 5 Years and Over Not Fluent in English	Median Household Income in 1999	Percent of Occupied Housing Units with No Vehicle Available
Medford Tracts					
Tract 3392	5.3%	6.2%	0.1%	$71,295	6.1%
Tract 3393	**46.9%**	18.8%	3.2%	$51,352	**15.8%**
Tract 3394	14.7%	17.5%	3.3%	$48,607	**19.7%**
Tract 3395	16.8%	17.9%	3.7%	$56,477	9.9%
Tract 3396	17.9%	20.4%	3.3%	$51,681	14.8%
Tract 3397	20.5%	**25.6%**	**7.3%**	$45,149	11.8%
Somerville Tracts					
Tract 3501	**42.4%**	**40.1%**	**16.4%**	**$40,436**	**22.3%**
Tract 3502	**28.3%**	**32.6%**	**6.7%**	$45,326	**19.8%**
Tract 3503	**28.5%**	**27.7%**	**7.2%**	$46,610	**16.3%**
Tract 3504	12.7%	14.9%	**4.3%**	$56,643	13.8%
Tract 3505	12.9%	13.8%	1.7%	$60,700	**19.2%**
Tract 3506	**22.6%**	15.9%	1.6%	$56,094	11.3%
Tract 3507	**21.8%**	**25.0%**	**6.0%**	$44,766	**29.1%**
Tract 3508	**22.2%**	18.1%	1.0%	$54,457	**19.3%**
Tract 3509	16.0%	16.9%	1.0%	$54,779	**19.2%**
Tract 3510	17.5%	20.2%	2.4%	$53,563	**19.2%**
Tract 3511	18.4%	**26.3%**	3.6%	$50,465	**21.1%**
Tract 3512	**27.4%**	**32.5%**	**7.3%**	$48,452	**28.2%**
Tract 3513	**25.5%**	**28.1%**	**8.1%**	**$33,516**	**33.7%**
Tract 3514	**47.7%**	**48.5%**	**19.0%**	**$36,113**	**25.0%**
Tract 3515	**35.2%**	**42.6%**	**20.1%**	**$36,516**	**32.6%**
Cambridge Tracts					
Tract 3521	**31.9%**	**28.2%**	1.7%	$48,529	**26.0%**
Tract 3522	**31.1%**	**31.9%**	**10.6%**	**$23,750**	**48.7%**

Bold indicates meets or exceeds EOEA and/or MPO EJ threshold

Additionally, the environmental justice populations defined by the EOEA and the Boston MPO have been consolidated onto one plan. Figure 3-5 shows each of the neighborhoods that have been categorized as environmental justice populations.

Figure 3-5 – Study Area Environmental Justice Communities



3.5 Roadways

As mentioned previously, a network of arterial and local roadways serves the study area. In general, the arterial roadways provide connections between the key activity centers within and beyond the area. Many of these arterial roadways also serve as commuter routes between more distant suburbs and the core business districts of Cambridge and Somerville. Intersections of these major arterial roadways often form the major commercial centers. Local roadways link residential areas to the arterials, and sometimes serve as cut-through routes to avoid traffic congestion during peak periods. Major roadways and the connections they serve are described in the next section.

3.5.1 Major Roadways

This section presents brief descriptions of major roadways within the study area. Where available, MassHighway traffic and accident data is provided. Supplemental traffic information and truck volumes were also provided by the City of Somerville.

- **Interstate 93** is the only interstate highway near the study area, running from the Massachusetts/New Hampshire border near Methuen to

Canton where it terminates at I-95. I-93 forms the southeastern boundary of the study area and serves as a major commuting route from the northern suburbs to downtown Boston. The only access to I-93 inbound near the study area is at the Route 28/38 intersection, adjacent to the Assembly Square Mall. Access from I-93 northbound is also possible at the Route 28/38 intersection and at a recently completed exit ramp to Cambridge Street/Washington Street near Sullivan Square on the Boston/Somerville city line. Access to and from I-93 north of the study area is available at the Mystic Avenue interchange on the Somerville/Medford city line. Supplemental connections between the study area and I-93 are also possible via Rutherford Avenue in Charlestown and via Leverett Circle in Boston. In the study area, I-93 carries nearly 150,000 vehicles per day with an average of 125 auto accidents per year.

- ☐ **Route 28/McGrath-O'Brien Highway** is a major multilane arterial that provides alternative connections from I-93 to Cambridge and downtown Boston. To the north of the study area, Route 28 is known as the Fellsway, which traverses Medford. To the south of the study area, Route 28 travels though Leverett Circle where connections are possible to the interstate system and Storrow Drive. Route 28 also provides important circulation functions within the study area linking Medford and the Assembly Square neighborhood to Winter Hill, East Somerville, and East Cambridge. Near Lechmere Station, Route 28 carries over 40,000 vehicles per day with 65,000 vehicles per day between Medford/Highland and Washington Streets. Approximately 170 auto accidents occur along this corridor annually. Observed truck volumes on Route 28 south of Medford Street are between 500 and 1000.
- ☐ **Route 38/Mystic Avenue** parallels I-93 offering access to commercial areas in Somerville and Medford and providing links to I-93 entrance and exit ramps. Mystic Avenue begins near Medford Square and ends near Sullivan Square in Charlestown. Mystic Avenue is generally a four-lane arterial carrying approximately 35,000 vehicles per day. Approximately 205 auto accidents occur annually along this corridor.
- ☐ **Route 16/Mystic Valley Parkway** travels through the northern section of the study area in an east-west direction linking Wellington Station and Alewife Station. Route 16 is generally a four-lane arterial roadway carrying approximately 20,000 vehicles per day. The corridor averages 236 auto accidents annually.
- ☐ **Route 60/High Street** travels through the northern section of the study area in an east-west direction linking Medford Square and Winthrop Square to West Medford. Route 60 is two-lane arterial roadway carrying approximately 18,000 vehicles per day with approximately 90 auto accidents a year.

- ❐ **Broadway** crosses the study area in a northwest-southeast direction linking Powderhouse Square near Tufts University to East Somerville and Sullivan Square via the Winter Hill neighborhood. Between Powderhouse Square and Sullivan Square, Broadway is generally a four-lane arterial roadway carrying between 20,000 and 30,000 vehicles per day. The corridor averages approximately 195 auto accidents a year. Truck volumes on sections of Broadway can be up to 499 trucks per day.

- ❐ **Washington Street** runs in an east-west direction across the southern portion of the study area, linking Union Square to Sullivan Square. In general, Washington Street is two-lane arterial roadway carrying approximately 11,000 vehicles per day and averaging 120 auto accidents a year. East of Route 28, there are 29,000 vehicles per day on this segment of Washington Street. Observed truck volumes on Washington Street range between 1000 and 2500 trucks per day.

- ❐ **Medford Street** crosses the study area in a north-south direction beginning in Medford Square as Main Street and crosses Harvard Street where it becomes Medford Street. Medford Street then enters Somerville as it crosses Broadway at Magoun Square and continues behind the Somerville City Hall/High School complex where it crosses the MBTA's Lowell Line at Gilman Square. Medford Street continues to the south and runs parallel with Route 28 to the east of Union Square. South of Somerville Avenue, Medford Avenue separates from Route 28, crossing the MBTA's Fitchburg Line and the Grand Junction Branch where it enters Cambridge and becomes Gore Street behind the Twin City Shopping Plaza. Gore Street terminates at Route 28 and the northwest corner of the existing Lechmere Station. In general, Medford Street is a two-lane arterial roadway carrying approximately 21,000 vehicles per day. On an annual average, 80 auto accidents occur along the Medford Street corridor through the City of Somerville. Observed truck volumes on sections of Medford Street can range from 0 to 499 trucks per day.

- ❐ **Highland Avenue** crosses the study area in an east-west direction, beginning at Davis Square, passing by Somerville Hospital and the Somerville City Hall/ High School complex and ending at Medford Street near its intersection with Route 28. Highland Avenue serves a critical function in connecting the primary commercial district of Somerville (Davis Square) with its government and medical centers. In many ways, Highland Avenue is a symbolic "Main Street" for Somerville. Highland Avenue is a two-lane roadway carrying approximately 13,000 vehicles per day, with approximately 90 auto accidents a year. Observed truck volumes on sections of Highland Avenue can range from 1000 to 1499 trucks per day.

- ❐ **Somerville Avenue** runs in an east-west direction along the MBTA's Fitchburg Commuter Rail Line, beginning at Porter Square and continuing through Union Square. The land uses fronting Somerville

Avenue are generally commercial or light industrial with residential neighborhoods located to the north of the roadway. Somerville Avenue ends at Route 28, approximately one mile west of Lechmere Station. Somerville Avenue is a two-lane roadway carrying approximately 8,000 vehicles per day, with approximately 18,000 vehicles per day at Bow Street and Somerville Avenue. Approximately 140 auto accidents occur annually on Somerville Avenue. Observed truck volumes on Somerville Avenue can range from 1000 to 2499 trucks per day in the vicinity of Union Square, and range from 1000 to 1999 trucks per day near Davis Square.

- **Elm Street** begins at Davis Square and connects to Somerville Avenue just to the east of Porter Square. Elm Street provides an important connection between Davis Square and Union Square via Somerville Avenue. Elm Street generally forms the southwestern edge of the study area and is a two-lane arterial carrying approximately 11,000 vehicles per day, with approximately 40 auto accidents a year. In the vicinity of Porter Square, there are approximately 15,900 vehicles per day. Observed truck volumes on Elm Street in the vicinity of Porter Square can range between 0 and 499 trucks per day.
- **College Avenue** begins at Davis Square and traverses the study area in a southwest-northeast direction. Approximately one-half mile northeast of Davis Square, College Avenue enters Powderhouse Square and turns to the north, traveling through the Tufts University campus crossing Boston Street and ending at Summer Street in the Medford Hillside neighborhood in Medford. College Avenue is generally a two-lane arterial carrying 11,000 vehicles per day. The auto accident rate along this corridor in Somerville is approximately 40 accidents per year.
- **Boston Avenue** enters the study area from West Medford and continues across Somerville and Medford in a northwest-southeast direction. Boston Avenue parallels the MBTA’s Lowell Commuter Rail Line and passes near Tufts University at its intersection with College Avenue. Boston Avenue then continues to an intersection with Broadway at Ball Square, where its character changes to that of a neighborhood residential street. Boston Avenue is generally two lanes and carries between 11,000 and 18,000 vehicles per day. Approximately 20 auto accidents occur along the Boston Street corridor within the City of Somerville.
- **Curtis Street/Winthrop Street** begins with Curtis Street at Teele Square to the northwest of Davis Square in Somerville and continues in a north-south direction to the Somerville/Medford City Line on the west side of the Tufts University campus. In Medford the roadway is named Winthrop Street and continues across the Mystic River into West Medford. Curtis Street/Winthrop Street is a two-lane roadway that carries between 8,000 and 10,000 vehicles per day. Approximately 15

auto accidents occur along this corridor annually. Curtis and Winthrop Streets generally form the northwestern boundary of the study area.

3.5.2 Congestion Management Areas

There are several locations within the study area that exhibit recurrent peak hour traffic congestion. In many cases, this traffic negatively impacts mobility for automobile traffic, truck traffic, and public transit operations. These locations are described qualitatively in the following sections. In many cases, these congestion management areas also correspond to locations with a high frequency of vehicle/pedestrian conflicts. Although the locations listed below are congestion points, many of the roadways within the study are characterized by narrow cross-sections, on-street parking, and high traffic volumes. All of these factors can contribute to traffic congestion.

- **Winthrop Square-** Winthrop Square is the intersection of High Street (Route 60/Route 38) and Winthrop Street (Route 38) and it is located along the northern edge of the study area. This intersection is controlled by a small rotary with all approaches yielding when entering the intersection. Moderate traffic congestion in this area can delay traffic flow along Winthrop Street, which connects to the Mystic River Parkway (Route 16).
- **West Medford Square -** West Medford Square is the intersection of High Street (Route 60), Playstead Road, and Harvard Avenue and it is located along the northern edge of the study area. This intersection is controlled by stop signs on the approaches from Playstead Road and Harvard Avenue. The MBTA Lowell Line railroad crossing is also located at the intersection. The railroad crosses High Street between Playstead Road and Harvard Avenue. The railroad crossing in this area can delay traffic flow along High Street, Playstead Road, and Harvard Avenue. Turns from the stop-controlled approaches on Playstead Road and Harvard Avenue can also be difficult during peak hours.
- **Main Street at South Street -** South Street carries traffic from Winthrop Street and Mystic Valley Parkway (Route 16) eastbound. South Street is a one-way roadway connecting to Main Street (Route 38) at a flashing signal. Directly across from South Street is the on-ramp to Route 16 eastbound. Moderate traffic congestion in this area can often delay traffic flow along South Street.
- **Mystic Avenue at Main Street -** Mystic Avenue (Route 38) intersects Main Street under stop control. The intersection is also controlled by a flashing traffic signal with pre-emption for the fire department located at the intersection. Moderate traffic congestion in this area can often delay traffic flow and bus operations along Main Street and impact emergency response vehicles.

- ☐ **Magoun Square -** Magoun Square is located on the northwestern edge of the study area and is formed by the intersection of Broadway, Medford Street, and Dexter Street. The intersection is controlled by a traffic signal with two-lane approaches along Broadway and one-lane approaches along Medford Street. Moderate traffic congestion in this area can often delay traffic flow and bus operations along Broadway and along Medford Street.
- ☐ **Teele Square -** Teele Square is the intersection of Broadway, Holland Street, and Curtis Street and is located along the western edge of the study area. This intersection is controlled by a traffic signal with pre-emption for the fire department located in the square. Moderate traffic congestion in this area can often delay traffic flow and bus operations along Broadway and along Holland Street.
- ☐ **Powder House Square-** Powder House Square is a complicated intersection of Broadway, College Avenue, Powder House Boulevard, and Warner Street near Tufts University. The intersection operates as a rotary with occasional traffic signal control on some approaches. Other approaches are controlled by STOP signs. Moderate traffic congestion is experienced in Powder House Square with delays to the Broadway approaches generally being more substantial than the other, lower volume approaches. Traffic flow and bus operations are often delayed at this intersection due to the unusual geometrics and traffic control, and high traffic volumes.
- ☐ **Davis Square -** Davis Square is the principal commercial center in Somerville. The square is characterized by a one-way circulation pattern along Elm Street (eastbound), Cutter Avenue (northbound), and Highland Avenue (westbound). Highland Avenue and Elm Street intersect with Holland Street, College Avenue, Dover Street, and Day Street at a signalized intersection. The MBTA Red Line Station is also located adjacent to this intersection. Traffic congestion in Davis Square is often moderate to severe during peak periods. Generally, the longest delays are along Elm Street westbound during the evening peak hour and on College Avenue southbound, entering Davis Square. These delays can influence transit connections to the Davis Square Red Line Station.
- ☐ **Temple Street and School Street at Broadway -** Temple Street and School Streets intersect Broadway at two closely spaced traffic signals. Temple Street carries traffic from the Mystic Avenue interchange along I-93 into Somerville. Much of this traffic then uses School Street to continue in a southerly direction across the City. The interaction of these two traffic signals, coupled with higher traffic volumes along Broadway and short queue storage distances can lead to some traffic congestion along this segment of Broadway.

- ☐ **McGrath Highway/Fellsway (Route 28) at I-93 -** Traffic congestion is common at this complicated interchange along I-93. The most common point of congestion is the Fellsway southbound approaching the intersection.

- ☐ **McGrath Highway at Broadway -**Although the traffic signals at this intersection along McGrath Highway are currently being reconstructed, the intersection can lead to traffic congestion on these major travel corridors. Congestion is especially prevalent when an incident on I-93 causes traffic diversions to the McGrath Highway. Similar conditions can occur many of the intersections along McGrath Highway such as the Pearl Street intersection located just to the south.

- ☐ **McGrath Highway at Medford Street/Highland Avenue -** Medford Street and Highland Avenue intersect McGrath Highway at a traffic signal. The geometric conditions at this intersection are complex given the acute intersecting angles of these roadways. In most cases, traffic congestion is more pronounced on Medford Street and Highland Avenue than on McGrath Highway. Much like the previous intersections along McGrath Highway, increased congestion can occur when traffic congestion on I-93 results in diversions to McGrath Highway. Recent improvements have been implemented in this area with three intersection projects, providing geometry improvements and interconnection between signals.

- ☐ **Union Square -** Many roadways intersect to form the Union Square area. These roadways include Washington Street, Prospect Street, Somerville Avenue, Webster Street, Newtown Street, Stone Avenue, Warren Avenue, and Bow Street. On the west side of Union Square, Bow Street (westbound) and Somerville Avenue (eastbound) form a one-way loop. The eastern end of this one-way loop is a signalized intersection with Washington Street and Webster Avenue, which is one way southbound. East of this signalized intersection, Somerville Avenue intersections Washington Street and Prospect Street at another signalized intersection. Both of these signalized intersections can be severely congested during peak periods. This congestion is most prevalent on Washington Street eastbound and westbound and Prospect Street northbound approaching the square. At many times of the day, Somerville Avenue is also very congested between the two traffic signals.

- ☐ **McGrath Highway at Washington Street -** Although the mainline of McGrath Highway passes over Washington Street, the surface intersection of ramps leading to and from Washington Street can be severely congested. The intersection is controlled by a system of traffic signals and has a very complicated geometry due to the space limitations imposed by the McGrath Highway overpass. Connections to several other roadways such as Medford Street, Linwood Street, and Somerville Avenue further contribute to traffic congestion at this location.

Additionally, traffic congestion from Union Square sometimes contributes to congestion at this location.

- **Sullivan Square -** Sullivan Square is located in Charlestown and is the intersection of Broadway, Mystic Avenue, Route 99, Main Street, Rutherford Avenue, and Cambridge Street (Washington Street). The square operates as a large rotary for most approaches although a traffic signal controls the westernmost intersection where Cambridge Street enters the rotary. Sullivan Station on the Orange Line is located adjacent to this intersection and an off-ramp from I-93 northbound provides access to Cambridge Street just to the west of the intersection. Until recently, an overpass provided expedited access I-93 from Sullivan Square. Recently this overpass was demolished, increasing the number of traffic movements made via the rotary. Traffic congestion at Sullivan Square is especially prevalent along Cambridge Street as it approaches Sullivan Station and the rotary. This congestion is influenced by the coordination of traffic signals at the I-93 ramp and at the eastern end of the rotary and can result in delays to traffic and transit operations. Congestion in this area could influence the viability of potential connections to the Orange Line and Commuter Rail at Sullivan Square.
- **O'Brien Highway at Land Boulevard/Charlestown Avenue (Gilmore Bridge) -** This intersection is located to the east of Lechmere Station on Route 28. Traffic congestion at this intersection is common, often resulting in substantial traffic delays on the Gilmore Bridge and Land Boulevard northbound. Traffic congestion is less frequent on O'Brien Highway and generally is associated with severe congestion on I-93 resulting in diversions to Route 28. Currently, this congestion management area does not impact transit operations since no bus routes travel beyond Lechmere Station on Route 28 or on Land Boulevard and the Gilmore Bridge. Travel through this area may be necessary if improved connections to North Station or Community College Station are developed as alternatives for this study.
- **Leverett Circle -** Although improvements are under construction by the Central Artery/Tunnel Project, recurrent congestion is expected to remain at this location and could impact the viability of bus route extensions to downtown that may be considered as part of this study.

3.6 Transit Services

This section provides an overview of the present-day routes, facilities, service patterns and ridership characteristics of the rapid transit, commuter rail and bus systems in the project area. Within the project study area, these facilities consist of three rapid transit lines, two commuter rail lines and many feeder bus routes.

3.6.1 Bus Service

The MBTA operates 15 bus routes in the study area. The following is a listing and description of the various bus routes provided by the MBTA.

No. 69: Harvard/Holyoke Gate – Lechmere Sta. via Cambridge St. – Route 69 is a local route that connects Harvard Square, Inman Square and Lechmere. The route travels up and down Cambridge Street between the two terminal stops. This route is located on the southern periphery of the study area connecting to Lechmere Station.

No. 80: Arlington Center – Lechmere via Powder House Square - The Route 80 is a local route connecting Arlington Center, Medford Hillside, Powder House Square, Magoun Square, Gilman Square and Lechmere Station. Most of this route is within the project study area, traveling along Boston Ave., College Ave., Broadway, Medford St., Pearl St., and the McGrath/O'Brien Hwy.

No. 85: Spring Hill – Kendall / MIT - Route 85 is a local route connecting Spring Hill, Summer Street, Union Square and Kendall / MIT. This route northern section, serving Spring Hill and Summer Street is within the project study area before traveling to Union Square where it runs along the same route as the CT2 to Kendall / MIT.

No. 86: Sullivan Square Station – Cleveland Circle via Harvard / Johnson Gate - This route connects Sullivan Square to Union Square, Harvard Square, Allston, Brighton and Cleveland Circle. The bus travels along Cambridge Street and Washington Street through the project study area providing service between Sullivan Square and Union Square. The MBTA's Preliminary 2004 Service Plan contains a recommendation to split this into two routes, each one starting or ending at Harvard Square to minimize schedule adherence problems. This change would not significantly affect the schedule of the route through the project study area.

No. 87: Arlington Center / Clarendon Hill – Lechmere Station via Somerville Avenue - This route connects Arlington Center, Clarendon Hill, Davis Square, Union Square, and Lechmere Station along Broadway, Elm Street and Somerville Avenue.

No. 88: Clarendon Hill – Lechmere Station via Highland Avenue - This route connects Clarendon Hill, Davis Square, Somerville High School, and Lechmere Station along Broadway, Holland and Highland.

No. 89: Clarendon Hill – Sullivan Square Station via Broadway - This route connects Clarendon Hill and Sullivan Station via Powder House Square and Winter Hill. The MBTA's Preliminary 2004 Service Plan contains a recommendation to split this route by alternating the northerly terminating stop between Davis Square and Clarendon Hill. The new diversion to Davis Square, called 89D, would travel between Sullivan Square and Powder House Square, as it currently does along Broadway, and then turn onto College Ave. to make the trip to Davis Square. This would improve the connection between Winter Hill and the Red Line.

No. 90: Davis Square – Wellington Station via Sullivan Square Station & Assembly Mall - This Route provides service between Davis Square and Wellington Station via Union Square and Sullivan Square.

No. 91: Sullivan Square Station – Central Square Cambridge via Washington Street - Route 91 connects Sullivan Square with Central Square (Cambridge) via Union Square and Inman Square.

No. 94: Medford Square – Davis Square Station via W, Medford & Medford Hillside - This route provides service from Medford Square to Davis Square. This route travels through the project study area along Boston Street and College Ave.

No. 95: West Medford – Sullivan Station via Mystic Ave. – The route 95 bus operates between West Medford and Sullivan Square serving the West Medford Commuter Rail Station and Medford Square. The route originates at the corner of Playstead Road and Winthrop St. and travels through the study area along Playstead Road, High Street and Mystic Avenue in Medford before serving the Sullivan Square Orange Line Station.

No. 96: Medford Square – Harvard Station via George Street & Davis Square Station - Route 86 operates between Medford Square and Harvard Square with an intermediate stop at Davis Square Station. This route utilizes Boston St. and College Ave. through the project study area just like Route 94, however the trip to Medford Square is much shorter since it travels along Winthrop Street and Main Street in Medford.

No. 101: Malden Station – Sullivan Sq. Station via Salem St., Main St. & Broadway - Route 101 connects Malden Center to Sullivan Square Station via Medford Square and Winter Hill. This route travels along Broadway and Main Street in the project study area.

No. 134: North Woburn - Wellington Station via Woburn, Winchester, Winthrop St., Medford Sq., Riverside Ave. & Meadow Glen Mall - Route 134 provides service between the three towns of Woburn, Winchester and Medford. In the study area the route travels through the community of West Medford along Winthrop Street, but does not serve the West Medford Commuter Rail Station.

No. CT2: Sullivan Square Station - Ruggles Station via Kendall / MIT -The CT2 Route is a limited stop, cross-town route that operates between Sullivan Square and Ruggles Station. This route utilizes Cambridge Street and Washington Street to travel between Union Square and Sullivan Square in the project study area.

Bus service frequencies and daily ridership on the project study area bus routes are shown in Table 3-10.

Table 3-10 – Bus Service Frequency and Ridership

Route	Daily Ridership	Number of Weekday Inbound Bus Trips 5-9:30am	9:30am-4pm	4-7pm	after 7pm	Total
No. 69	3,388	15	20	9	13	57
No. 80	1,872	13	13	8	7	41
No. 85	402	7	9	4	0	20
No. 86	5,139	17	18	8	7	50
No. 87	3,720	14	15	11	11	51
No. 88	4,299	18	16	11	12	57
No. 89	3,586	21	17	6	9	53
No. 90	1,280	5	9	5	4	23
No. 91	1,482	11	15	6	6	38
No. 94	1,343	11	9	9	10	39
No. 95	1,679	13	13	9	7	42
No. 96	1,458	12	10	9	10	41
No. 101	4,323	21	14	13	7	55
No. 134	1,605	11	14	7	7	39
No. CT2	1,192	9	13	9	0	31

3.6.1.1 Bus Safety and Comfort

The MBTA has a Service Delivery Policy to "ensure that the MBTA provides quality transit services that meet the needs of the riding public." The 2004 Service Plan updates and revises the 1996 Service Delivery Policy and incorporates changes that were approved in 2002 and 2004.

A portion of the Service Delivery Policy identifies Service Objectives and Standards used to evaluate the MBTA's service performance. The Service Standard for Safety and Comfort is vehicle loading. The average load standard for Bus Service is shown in Table 3-11. These standards are calculated using an average maximum vehicle load per trip over any 30 to 60 minute period.

Table 3-11 – MBTA Bus Loading Standards

Time Period	**Passengers/Seat**
Early AM, AM Peak, Midday School & PM Peak	140%
Midday Base, Evening, Late Evening, Night/Sunrise &Weekends	
Surface portions of routes	100%
Tunnel portions of routes	140%

3.6.1.2 Loading Evaluation

The 2004 Service Plan contains a Summary Analysis of Routes and Proposed Changes (Appendix A) that notes which routes meet or fail to meet each standard in the Service Delivery Policy. Of all the bus services that are included in the study area only the Route 86 service does not meet the Bus Load standard, according to this summary. However, the peak load route segment of concern on Route 86 is between Brighton Center and Harvard Square, which has loads about 45% greater than those experienced on the segment between Sullivan

Square and Harvard Square. The traffic congestion along the entire route results in delay to the service and limits the ability to add significant capacity. In addition this route has one of the most frequent headways of those operating in the study area.

3.6.1.3 Service Reliability Standards

The portion of the Service Delivery Policy that deals with on-time performance or reliability includes a Schedule Adherence Standard that is used to quantify the performance of each service and how well it adheres to the published schedules. The goal is to identify services that do not meet the standard, identify the problem and to take some corrective action, where possible. The specific standards vary by the scheduled frequency of the route. Routes are divided into walk-up service, where the service operates more frequently than every 10 minutes, and scheduled departure service, where headways are greater than 10 minutes. Until early this year, schedule adherence on buses was measured according to a standard in the 1996 Service Delivery Policy, as amended in 2002. In late 2004, the MBTA adopted a new Service Delivery Policy intended to make the bus schedule adherence standard more sensitive to variations between routes. Table 3-12 provides a summary of the current and former standards.

Table 3-12 – Summary of Bus Schedule Adherence Standard

Standard in 2004 Service Plan (adopted September 2004)			
Trip Test	**Beginning of Route**	**Mid-Route Time Point(s)***	**End of Route**
Scheduled Departure Trips (Headways ≥10 min.)	Start 0 min. early to 3 min. late	Depart 0 min. early to 5 min. late	Arrive 3 min. early to 5 min. late
Walk-up Trips (Headways <10 min.)	Start within 25% of scheduled headway	Leave within 50% of scheduled headway	Running time within 20% of scheduled running time
Route Test	For any given bus route to be in compliance with the Schedule Adherence Standard, 75% of all trips on must adhere to the above measures over the entire service day.		
*For Schedule Adherence, mid-route time points will be used only for routes on which the on-time performance data has been collected using CAD/AVL equipment.			

Standard in 1996 Service Plan (as amended in 2002)	
Adherence Standard	
Headways >= 10 minutes	75% of all trips departing and arriving 0-5 minutes late at both terminals over an entire day
Headways < 10 minutes	85% of all trips within 1.5 headways over an entire day
Trip Time Standard	95% of all trips no more than 5 minutes greater than scheduled trip times by time period and duration

3.6.1.4 Schedule Adherence Evaluation

According to the summary in the 2004 Service Plan, all study area bus routes except Route 85 failed to meet the schedule adherence standard from the 1996 Service Plan (as amended in 2002). Systemwide, only 11% of the MBTA's weekday bus routes met this schedule adherence standard. While no data are available yet about how routes are performing in relation to the new schedule adherence standard, this new standard should help the MBTA focus efforts on improving routes that have problems running significantly late. The new standards also anticipate the implementation of Computer-Aided Dispatch/Automated Vehicle Location (CAD/AVL) as new buses are added to the fleet. This new technology will allow the MBTA to verify the accuracy of the mid-route time points on the schedule cards, and once the Bus Central Dispatch system has been fully implemented, it will be possible to track real time schedule adherence and to instruct drivers to make headway adjustments if needed.

3.6.1.5 Bus System Improvements

In the 1990s and until this past year, the MBTA bus fleet that operated in the project study area was composed mostly of 40 foot, high-floor, diesel powered transit buses from various manufacturers dating back to the mid 1980's. However that has changed as the MBTA has embarked on an aggressive fleet modernization program. Ongoing improvement initiatives include:

- A large-scale upgrade of the MBTA bus fleet, with the recent procurement of 546 new buses with either CNG or Emissions Control Diesel (ECD) engines. The new buses are of a low floor configuration. With the recent and planned bus procurements the average age of the MBTA bus fleet has been reduced from 13 years in 2003 to just 4 years in 2005.
- Many of these buses will collect data that can be used to set better schedules and make route changes when congestion is a problem.
- All of the existing buses manufactured since 1990 are being overhauled, to accommodate use of low emission diesel.
- Many of the MBTA's bus maintenance garages have reached their capacity. The MBTA has plans to expand existing facilities and/or construct garages to provide additional capacity. In the Beyond Lechmere study area, all of the study area bus routes are operated out of the MBTA's Charlestown Garage, with the exception of Routes 94 and 96 which operate out of the Fellsway Garage in Medford on weekdays and out of Charlestown on weekends (when the Fellsway facility is closed). The MBTA is planning for a new bus garage and maintenance facility to be constructed at Wellington Station within the next decade. This facility is intended to provide additional capacity and replace older garages such as the Fellsway facility

In the near term, the MBTA's standard bus fleet will consist of approximately 300 CNG vehicles manufactured by North American Bus Industries and New Flyer Industries in 2001-2004; 175 ECD buses manufactured by Neoplan in 2004; and 396 conventional diesel buses manufactured by TMC and Nova between 1994 and 1995, which are being overhauled in the 2004-2007 time frame. An additional fleet of 44 articulated buses manufactured by Neoplan with CNG propulsion are in service on selected high-volume routes. A decision on the use of ECD or CNG technology in future bus procurements will depend on the performance of the vehicles now being operated by the MBTA.

Based on the bus assignments by garage as of April 15, 2005, approximately 20 percent of the fleet available for service on the study area routes is comprised of new low floor ECD buses manufactured by Neoplan. The balance of the available fleet for the study area consists of conventional diesel buses manufactured by Nova/TMC, which are being put through the overhaul program.

In addition to the fleet modernization and maintenance facility improvements described above, the MBTA is also working to improve schedule adherence on Route 86, which experiences significant problems with schedule adherence. It appears that the schedule adherence problem is a result of the route's length and heavy congestion. These factors, coupled with heavy boardings and alightings at the mid-point in Harvard Square, result in significant delay problems. In the 2004 Service Plan, it was recommended that Route 86 be split into two routes at Harvard Square. These routes would operate at the same frequency at all times of day. They would be interlined, so customers riding through Harvard Square would find it easy to continue doing so. The bus would arrive at Harvard Square as one route, remain there for about thee minutes to assure schedule adherence, and then continue on as the next route. In the service changes adopted with the 2004 Service Plan, a less extensive change to the route was adopted in which a three-minute hold time was added at Harvard Square to allow for schedule correction.

3.6.2 Green Line (Rapid Transit / Light Rail)

Lechmere Station, situated in Cambridge at the southern periphery of the project study area, serves as the northern terminus for the MBTA's Green Line light rail system. In its existing configuration Lechmere Station is an at-grade facility located immediately west of the Msgr. O'Brien Highway. This is essentially a "turnback" facility equipped with loop tracks, limited storage capacity for light rail cars and no maintenance facilities. Developers of the North Point complex, located east of the Msgr. O'Brien Highway, have committed to participate in the construction of a new Lechmere Station within the development complex. This would provide a modern terminus, well positioned to access the nearby commuter rail rights-of-way. The conceptual plans in the project's Environmental Impact Report included layover space at or near the station for approximately 24 cars, an increase over the layover capacity of the existing Lechmere Station of approximately 20 cars. South of existing Lechmere Station, the alignment of the Green Line crosses over to the east side of the Msgr. O'Brien Highway on an elevated causeway, extending south to Science Park and North Station. The MBTA in 2004 completed the new Green Line – Orange Line

Station located underground at North Station, and demolished the elevated Green Line structure on Causeway and Nashua Streets.

South of North Station, the Green Line operates through a series of downtown tunnels termed the "Central Subway." Once through the Central Subway, the Green Line branches into four separate routes that emerge from underground in the vicinity of Kenmore Square (Boston College, Cleveland Circle and Riverside Lines) and at Northeastern University on Huntington Avenue (Heath Street Line). These southern branches have been variously through-routed to terminal points at Park Street, Government Center, North Station and Lechmere. At present, the designated terminal points are:

❒ Route B	Boston College – Government Center
❒ Route C	Cleveland Circle – Government Center
❒ Route D	Riverside – Lechmere
❒ Route E	Heath Street – Lechmere

The Route A designation is vacant, having been assigned to the now-discontinued Oak Square / Watertown Line. The Boston College, Cleveland Circle and Heath Street branches operate at-grade in mid-street reservations and in mixed traffic. This results in the service being subjected to traffic-generated delays. Such delays are often mitigated by turning the northbound trains around prior to reaching their northern destinations (i.e. at Park Street or Government Center instead of Government Center or Lechmere, respectively). The Riverside – Lechmere route (D Line) is the longest on the Green Line, encompassing 13.4 miles.

Daily ridership on the Green Line, as measured by passenger boardings, is 225,200 passengers.[1] The afternoon west-bound peak hour load volume of approximately 5,000 passengers, which occurs between Arlington and Copley Stations, represents approximately 82% of existing Green Line system capacity.[2] This is in contrast to the east-bound morning peak hour load volumes between Copley and Arlington which run at or over capacity. Combined, on a typical weekday the central subway portion of the Green Line operates at 81% of capacity during the peak 30 minutes.[3] Table 3-13 shows typical weekday boardings at stations on the central subway portion of the Green Line for the most recent reporting year.

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[1] MBTA website (www.mbta.com)

[2] Source data: 1997 Passenger Counts: MBTA Rapid Transit and Green Line Central Subway Volume I and Volume II, Central Transportation Planning Staff.

[3] Mobility in the Boston Region, Existing Conditions and Next Steps, Central Transportation Planning Staff, December 2004.

Table 3-13 – Green Line Typical Weekday Boardings (1997)

Station	Boardings
Lechmere	5,421
Science Park	1,360
North Station	4,906
Haymarket	4,465
Government Center	14,263
Park Street	10,445
Boylston	5,934
Arlington	8,790
Copley	13,777
Hynes	8,759
Kenmore	7,610

Source: MBTA Ridership & Service Statistics, Ninth Ed. (2003-04)

Green Line trains are comprised of three types of equipment: Light Rail Vehicles (LRVs), Type 7 cars and Type 8 cars. LRVs were built by Boeing Vertol in 1976-1978. Presently, 40 of these cars remain in service, used primarily in peak periods. The bulk of the fleet consists of so-called Type 7 cars built in 1984-1988 by Kinki-Sharyo. This fleet consists of 111 active vehicles. The LRV and Type 7 cars require the use of multiple steps to board the vehicle, since the Green Line operates with low-level platforms. Platform heights are being increased at key stations to enable wheelchair passengers to access the low floor section by means of a short ramp. The Green Line vehicles are powered by an overhead electrified trolley wire and catenary system energized at 600 volts. The total active fleet as of April 2005 was 175 cars cars, with 144 cars being required for the afternoon peak period. The Green Line's primary maintenance, repair and storage facility is located at Riverside. Additional storage yards and light maintenance facilities are located at Reservoir (end of the Cleveland Circle Line) and Lake Street (end of the Boston College Line). At the north end of the Green Line, Lechmere provides overnight storage capacity for 21 cars. No maintenance or repair work is performed at Lechmere.

Green Line trains typically consist of one and two cars, although a few three car trains have been operated during peak periods, subject to equipment availability. The three vehicle types are not interchangeable, and multiple car trains must be comprised of like equipment. As part of the Type 8 Breda car procurement, the MBTA is modifying propulsion and control systems on the Type 7 cars so that the two equipment types can operate together in multiple car trains.

Peak period schedules provide for service frequencies (headways) of five minutes on both the Boston College and Riverside Lines, six to seven minutes on the Cleveland Circle Line and seven minutes on the Riverside Line. As these services meet in the Central Subway, the result is a peak hour combined service volume of 43 trains per hour in each direction in the Central Subway, or headways of approximately 90 seconds. Green Line car requirements and headways are summarized in Table 3-14 (where **T** = Number of trains, L=Cars per train and *H* = headway in minutes):

Table 3-14 – Green Line Car Requirements and Headways

Route	**AM Peak**			**Am Base**			**PM Base**			**PM Peak**			**Late**		
	T	L	*H*	**T**	L	*H*	**T**	L	*H*	**T**	L	*H*	**T**	L	*H*
Boston College	**20**	2	*5*	**12**	2	*8*	**12**	2	*8*	**20**	2	*5*	**11**	1	*8*
Cleveland Circle	**13**	2	*6/7*	**13**	1	*6*	**13**	1	*6*	**13**	2	*6/7*	**7**	1	*10*
Riverside	**24**	2	*5*	**12**	2	*10*	**12**	2	*10*	**25**	2	*5*	**11**	1	*10*
Heath Street	**12**	2	*7*	**8**	2	*9*	**8**	2	*9*	**12**	2	*7*	**8**	1	*10*
Run as Directed	**4**	1					**1**	1		**4**	1				
Total Cars Required	**142**			**77**			**78**			**144**			**37**		

3.6.3 Red Line (Rapid Transit / Heavy Rail)

From downtown Boston the Red Line extends northwest to a terminus at Alewife Station, passing through Cambridge and the western portion of Somerville. In the project study area, stations are located at Davis Square and Porter Square. A station is also located nearby in Cambridge at Kendall Square. Daily boardings at each of these stations are as follows: Davis-10,695, Porter - 7,355, and Kendall – 11,218. The Porter Square station includes a commuter rail connection to the Fitchburg Line. Davis Square includes a number of feeder bus routes and is located at the west end of a linear park / pedestrian path, which is intended to extend east towards Lechmere.

The Red Line is a heavy rail, high platform, grade separated operation, powered by a third rail system. Trains consist of multiple cars (six cars during peak periods and four cars during the off-peak). The active fleet consists of 218 cars. The oldest group of cars, totaling 74, was constructed in 1969-70 and was rebuilt in 1985-88. An additional 58 cars of similar design were constructed in 1987-89. A newly designed fleet of 86 cars was procured in 1993-94. South of downtown Boston, the line splits into two branches terminating at Braintree and Ashmont stations. The distance from Alewife to Braintree is 17.7 miles; from Alewife to Ashmont the distance is 11.9 miles. Service frequencies on each branch are approximately eight minutes during the peak periods and twelve minutes during the off-peak. From downtown Boston north to Cambridge and Somerville this results in a combined service frequency of four minutes during the peak period and six minutes during the off-peak. The line was extended north from Harvard Square through Porter and Davis Squares to Alewife during the early 1980's. The subsequent commercial and residential development in the areas surrounding these locales is considered indicative of the economic and social benefits that can accrue from such transit facilities.

Daily ridership on the Red Line is 214,200 passenger boardings. The morning peak hour passenger load volume is 9,500 passengers occurring between South Station - Broadway - Andrew Stations. Table 3-15 summarizes typical weekday station entrances at key Red Line stations for the most recent reporting year.

Table 3-15 – Red Line Typical Weekday Station Entrances (1997)

Station	Entrances
Alewife	9,409
Davis Square	10,695
Porter Square	7,355
Harvard	20,212
Kendall	11,214
Charles/MGH	7,855
Park Street	6,535
Downtown Crossing	12,381
South Station	20,778

Source: MBTA Ridership & Service Statistics, Ninth Ed. (2003-04)

3.6.4 Orange Line (Rapid Transit / Heavy Rail)

The Orange Line extends from Forest Hills in Jamaica Plain to Oak Grove in Malden, a distance of 10.8 miles. Within downtown Boston, the line operates in a subway. South of downtown Boston, the line is located in an open cut alongside the commuter rail and Amtrak Northeast Corridor right-of-way. North of Boston, the line is located in a grade separated right-of-way alongside the MBTA's Haverhill/Reading commuter rail line. At the eastern periphery of the project area, the Orange Line provides service parallel to the Green Line between North Station and Sullivan Square Station. Wellington Station, the next station north beyond Sullivan Square, is a major park-and ride facility, with over 1,300 spaces. Although Wellington is located beyond the project area, the parking facilities are large enough to serve a regional market, so that some project area residents may use them.

The Orange Line includes three tracks between Community College and Wellington stations. When the reconstruction of the northern portion of the Orange Line was designed in the late 1960's, it was intended that the two outside tracks would be the normal northbound and southbound tracks while the inside track would be a reverse express track. MBTA long-range planning at that time envisioned extension of the various rapid transit lines outwards to the Route 128 corridor, and this track configuration anticipated the eventual extension of the

Orange Line to Reading. However, the line has never been operated with an express track service. Instead, the third track has been used for testing of vehicles, signals and train control equipment.

The City of Somerville is examining the feasibility of constructing a new Orange Line station at Assembly Square, located mid-way between Wellington and Sullivan Square Stations. The Assembly Square station is intended to serve as an important adjunct to the re-development of the Assembly Square by facilitating commercial and residential development at the site. The positioning of a new station at an intermediate location on the Orange Line raises issues pertaining to train travel times, passenger volumes and the impact on capacity at peak load points on the line. These issues are being investigated by the City of Somerville in consultation with the MBTA.

The Orange Line is a high platform, third rail operation that uses a fleet of 120 cars constructed in 1979-81. Service frequencies range from five minutes during the peak hour to a range of eight to thirteen minutes during off-peak periods. All trains are scheduled to operate the entire length of the line. Trains consist of six cars at all times. The MBTA is currently upgrading the signal system on the northern portion of the line, with the intent of improving service reliability. Daily ridership is 160,900 passengers with the morning peak hour load volume of 8,200 passengers occurring between North Station and Haymarket Station. Table 3-16 summarizes typical weekday station entrances at key Orange Line stations for the most recent reporting year.

Table 3-16 – Orange Line Typical Weekday Station Entrances (1997)

Station	Entrances
Oak Grove	4,582
Malden Station	10,335
Wellington Station	7,078
Sullivan Station	8,667
Community College	3,663
North Station	8,312
Haymarket	4,162
State	11,249
Downtown Crossing	13,102

Source: MBTA Ridership & Service Statistics, Ninth Ed. (2003-04)

3.6.5 Commuter Rail Services

3.6.5.1 New Hampshire Main Line

The New Hampshire Main extends northwest from Boston's North Station through Somerville and Medford to Lowell, which is the present terminal for commuter rail service on the line. The MBTA identifies the route as the "Lowell Line" in its published schedules. The route continues northwards into New Hampshire. The Boston – Portland intercity passenger rail service operated by Amtrak as the "Downeaster" also uses this route. Freight service is operated by Guilford Transportation Industries. The State of New Hampshire, in cooperation with the Massachusetts Executive Office of Transportation & Construction, is proceeding with the initial design and operations planning for an extension of commuter rail service to Nashua, New Hampshire. From Boston through Lowell to the New Hampshire state line, the line is owned by the MBTA.

The route is also used by a few trains operating on the MBTA's Haverhill / Reading Line. Due to track capacity considerations, these trains are routed over the New Hampshire Main Line between North Station and Wilmington as non-stop trains.

Current Lowell Line commuter rail service consists of 21 inbound and 21 outbound weekday trains. Weekend and holiday service consists of eight inbound and eight outbound trains. In 2001, the MBTA opened a large intermodal station on the line in Woburn, the Anderson Regional Transportation Center, which provides parking and Logan Express Bus connections for passengers in the vicinity of Route 128 / I-95. A passenger station at Tufts University was closed in the early 1980's due to low passenger volume and the desire to reduce travel time to Boston for passenger from outlying areas. At the northern end of the study area, the West Medford station is served by all of the scheduled commuter rail trains. Travel time from Lowell to Boston is approximately 50 minutes. Travel time between West Medford Station and Boston is approximately 12 minutes. Daily ridership generated by the West Medford Station is 478 passenger boardings.

In keeping with MBTA operating standards for its "North Side" commuter rail lines, all trains consist of single level commuter rail coaches operated in push – pull configuration with the locomotive typically located at the outbound (or northern) end of the train. Maximum train lengths typically are six cars. Additional train capacity could be achieved in the near to mid term by increasing train lengths to nine cars, subject to equipment availability. Long-term MBTA capital improvement plans call for the replacement of the single level coaches with higher capacity bi-level coaches.

Daily weekday ridership on the Lowell Line service is approximately 10,000 passenger boardings, based on December 2003 ridership counts. Table 3-17 shows typical weekday inbound boardings at each Lowell Line Station.

Maximum train capacity, based on the use of six-car trains, is 825 passengers. The greatest ridership on a morning peak period train is 795 passengers representing 96 percent of train capacity.

Table 3-17 – Lowell Line Daily Weekday Boardings by Station

Station	Daily Weekday Inbound Boardings
Lowell	1,341
North Billerica	737
Wilmington	450
Anderson	832
Mishawum	22
Winchester	677
Wedgemere	454
West Medford	478

Source: MBCR 12/03

Although the focus of the MBTA's commuter rail service is toward Boston as an employment center, the Lowell Line experiences some reverse commuting. The primary destination for any reverse commuter on the Lowell line is Woburn. In the Spring of 2000, approximately 80 riders used the commuter rail service to travel on the 4 peak period trains to the Mishawum station. In addition, 10 passengers utilized the Lowell Line to travel between North Station and West Medford.

From Boston through Somerville the line was originally constructed with multiple tracks (three and four tracks in some locations). Reconstruction of the trackage by the MBTA has resulted in a double track route, albeit with sufficient right-of-way being available for the installation of additional trackage or other transit services. Recent overhead highway bridge construction at some locations has resulted in some side clearance limitations due to bridge abutments, and these will need to be investigated in conjunction with the project's proposed alternatives. In Somerville, all roadways, which cross the right-of-way, are grade separated from the tracks. Within the study area in Medford, only two at-grade crossings exist at Canal Street and at High Street adjacent to the West Medford Commuter Rail Station.

3.6.5.2 Fitchburg Division

The Fitchburg Division extends from North Station through Cambridge, Somerville and then westward to Fitchburg. Within the project area the route passes along the west side of the MBTA's Commuter Rail Maintenance Facility in Somerville, continuing west through Union Square, paralleling Somerville Avenue. The route then passes through Porter Square in Cambridge, Waltham, Concord and South Acton with a terminus in Fitchburg. Commuter rail service on this route consists of 18 inbound and 18 outbound trains on a weekday. Of these 18 trains, five inbound and outbound trains originate / terminate at South

Acton. Travel time between Boston and Fitchburg is approximately 1 hour and 20 minutes. Travel time between Boston North Station and Porter Square is 11 minutes.

The MBTA in February 2004 inaugurated express service on this route, with trains operating non-stop between South Acton and Porter Square, thereby reducing travel time by approximately 10 minutes. Sunday and holiday service consists of seven inbound and outbound trips, with reduced frequencies between South Acton and Fitchburg. Eight inbound and outbound trips are operated on Saturdays.

Daily weekday ridership is approximately 8,000 passenger boardings. Trainset capacity, based on a six-car train, is 825 passengers. Table 3-18 shows typical weekday inbound boardings at each Fitchburg Line Station. The greatest ridership on a morning peak period train is 563 passengers (based on December 2003 counts) representing 68 percent of the train’s capacity. The Porter Square Station generates approximately 143 daily inbound boardings.

Table 3-18 – Fitchburg Line Daily Weekday Boardings by Station

Station	Daily Weekday Inbound Boardings
Fitchburg	155
North Leominster	172
Shirley	139
Ayer	233
Littleton/495	154
South Acton	560
West Concord	437
Concord	426
Lincoln	262
Silver Hill	5
Hastings	55
Kendal Green	111
Brandeis/Roberts	449
Waltham	488
Waverley	131
Belmont Center	113
Porter Square	143

Source: MBCR 12/03

Although the focus of the MBTA’s commuter rail service is toward Boston as an employment center, the Fitchburg Line does experience some reverse commuting. The primary destination for any reverse commuter on the Fitchburg line is Waltham. In the Spring of 2000, approximately 75 riders used the commuter rail service to travel on the 3 peak period trains to the Waltham and/or Brandeis/Roberts stations. In addition, 25 passengers utilized the Fitchburg Line to travel between North Station and Porter Square.

Within the project area, this route was constructed as a multiple track right-of-way, with many freight sidings in the industrial area of Union Square. Many of the sidings have been removed and the line operates as a double track rail corridor with sufficient right-of-way available for additional track or other transit services.

Within the project area the tracks are grade separated. Freight service on this MBTA-owned route is operated by Guilford Transportation Industries. Train configuration and equipment is the same as for the New Hampshire Main Line.

3.7 Development Patterns

3.7.1 Economic Development/Land Use

Understanding the urban setting in which the transit system functions beyond Lechmere is crucial in defining the goals and the realistic alternatives to consider. Any extension would need (1) to fit into the existing land use of the area, (2) comply with local land use development plans, (3) accommodate an established street network and defined open spaces, with real dimensions and physical constraints, (4) serve activity areas and (4) provide connections to riders' origination points.

3.7.1.1 Existing Land Use Patterns

The topography of the study area is hilly (including Prospect Hill, Central Hill, Winter Hill, and the Medford Hills). The area also features a ridge that is oriented approximately west-east and runs along Highland Avenue. Street alignments roll down to the north and to the south from the ridge. The high ground areas around Prospect and Central Hills offer glimpses of Downtown Boston's high-rise structures.

The study area is a typical dense early 20th-century urban setting. Double and triple-deckers are distributed around urban centers that attract city activities, and a number of main avenues collect and funnel the vehicular traffic. The urban centers or activity areas that must be considered in their proper context are:

- **Davis Square,** in 1997, was declared one of the 15 "hippest" neighborhoods in the United States, a designation inconceivable without the 1984 arrival of MBTA's Red Line. While this square resides outside the study area of this project, it is a model for coordination of transit investment and urban economic revitalization initiatives. Since the opening of the Red Line station in 1984, the station has seen increased activity with station entrances rising from 6,565 in 1988 to 8,377 in 1992 and the most recent counts conducted in 2001-2003 being 10,695. During this same period, station entrances at other area Red Line stations remained relatively steady. This increase in station entrances is likely an indicator of the increased commercial activity in the Davis Square area.

- **North Point** is the 45-acre area located south of the Fitchburg commuter rail line and north of the serpentine boundary line that separates Somerville and Cambridge. North Point has been part of a planning initiative undertaken by the City of Cambridge to promote a new dense urban neighborhood in the city of Cambridge. The area is within the Charles River Basin area between the Charles River Esplanade and Boston's Harbor Park Envisioned is mixed-use development that includes 2,700 housing units, 2.1 million square feet of commercial space for office laboratory and retail uses, and a 90-room hotel.
- **Union Square** bears striking similarities to, and has the potential to become if served by transit, another Davis Square. While presently developed with a lower-intensity mix of small businesses, restaurants, and housing, it has considerable potential in the eyes of the City of Somerville officials to become an economic catalyst, given its proximity to Inman and Harvard Squares in Cambridge. Union Square plays the role of a hinge between a light industrial area that lies along the eastern end of Somerville Avenue, the commercial establishments at the intersection of Prospect, Bow and Washington Streets, and the residential areas north of Bow and Summer Streets. Union Square connects with the Central Hill area via Walnut Street. The City in conjunction with the community has recently completed several major planning documents for future investment in the square, including a Master Plan, Transportation Plan, and the establishment of a Neighborhood Revitalization Strategy Area.
- **Inner Belt Industrial Park/Cobble Hill/Brickbottom** is the area between Washington Street and Lechmere Station bound by the Lowell Line and the Fitchburg Line. The Inner Belt is the closest commercial area in Somerville to Lechmere Station and Boston. The Industrial Park is accessible only from Washington Street via an underpass below the Mystic Piers Branch Railroad. This connection does not provide easy roadway, pedestrian or transit access to this development area. The Industrial Park is also separated from the emerging North Point District of Cambridge by the Fitchburg Line and the Grand Junction Branch. The area is further separated from the Hood Industrial Park and Sullivan Square Orange Line in Charlestown by the I-93 and the Orange Line and commuter rail tracks. The Brickbottom area is approximately 40 acres located west of Route 28 and east of the Inner Belt.
- **City Hall Square/Gilman Square** is the civic center of Somerville and lies at the intersection of Highland Avenue and School Street, extends along Highland Avenue to Walnut Street and then wraps around the high school complex to Medford Street across the bridge over the MBTA right-of-way to Gilman Square, behind City Hall. It appears that, for

reasons of location and importance to the city, this site could be a prime candidate for a transit station.

- **Ball Square** is located at the important intersection of Broadway and the Lowell Line right-of-way. Ball Square would be well suited as a stop on any transit service from Lechmere to Medford Hills. The Square is healthy commercial center with retail, stores, cafes and restaurants.
- **Medford Hillside** is the area extending north from Powderhouse Square through Tufts University and over the Mystic River into West Medford. With its residential, educational and commercial land uses, it is an important center in the study area that could support improved transit service. Boston Avenue is a primary roadway through Medford Hillside that has urban centers and activity centers at the intersection of Winthrop Street and along the section from College Avenue to Arlington Street.
- **West Medford Square** is a business district in close proximity to residential areas. The intersection of Route 60/High Street and Playstead and Harvard Avenues is a congested area. Surrounding West Medford Square, there exist businesses, restaurants, churches, schools and residences, as well as the MBTA's West Medford Commuter Rail Station.

3.7.1.2 Economic Development Initiatives

As alluded to above, the introduction of public transit has resulted in substantial economic development in the Davis Square area. Although the majority of the study area is densely developed, expansion of public transit to new areas could have positive effects on economic development, if done in concert with local planning efforts and land use regulations. This economic development could result from redevelopment of underutilized parcels, such as former industrial properties and surface parking lots, or from renovation and reuse of existing buildings.

Most of the study area consists of high-density urban neighborhoods which are established yet experiencing growth pressures and demographic change. Given that roadway expansion is not possible and space for cars is extremely limited, it will be difficult if not impossible to meet the goals of regional housing affordability and concentrated mixed-use development while relying on an auto-dependent transportation system. Therefore, there is a need to strengthen and expand transit options for economic development to occur.

Two areas have been identified by the City of Somerville as high priority areas for economic development:

- **Union Square**. Substantial development opportunities exist near Union Square. Underutilized industrial properties are located on the southeast side of the square adjacent to the Fitchburg Branch railroad corridor.

Additional development opportunities exist in the square itself through renovation of existing buildings, renovation of existing buildings. Similar potential exists both to the east and west of the square along Somerville Avenue.

- **Inner Belt Industrial Park/Cobble Hill/Brickbottom**. To the east of Union Square, the mixed-use district east of Route 28 could exhibit substantial economic development with the addition of improved transit service. The Inner Belt Industrial Park could be transformed into a prime location for additional light industrial, research & development, office, or mixed use development. Additional development opportunities are also possible in the Brickbottom area.

In addition to these primary redevelopment areas, additional opportunities exist throughout the study area:

- Gilman Square could provide mixed-use development opportunities near a potential transit station. Such development could help to address the topographic challenges of the area and improve access to the City Hall/ High School complex from the potential station area are points to the north.
- The area between the Lowell Line and the former railroad right of way to Alewife (Somerville Community Path Alignment) contains abandoned industrial properties which could serve as prime residential development sites.
- The area along Boston Avenue between Ball Square and Winthrop Street could hold some redevelopment potential for institutional, residential, or mixed uses.
- Increased residential and commercial activity is also possible near a number of locations along the Lowell Line, including Magoun Square, Medford Hillside, Ball Square, Winthrop Square and West Medford.

3.7.2 Transportation Corridors

As described earlier in this document, a variety of roadway corridors provide vehicular circulation. For the most part, however, these corridors have limited capacity to accommodate a large volume of additional bus service, or to provide improved service reliability and quality due to their narrow right-of-way, high traffic volumes, and on-street parking. Notable exceptions to this condition are the McGrath Highway, Somerville Avenue between McGrath Highway and Union Square, and Broadway between Ball Square and Sullivan Square.

Railroad corridors in the study area include the Fitchburg Line, the Lowell Line, and the Somerville Community Path right-of-way (among others in East Somerville). These rights-of-way provide the opportunity for off-road transit service and access to the main economic development areas described in the previous section. There are constraints on the ability of these rights-of-way to provide increased transit service. These constraints include:

- The right-of-way is used for both commuter rail and freight services. Impacts on existing services need to be minimized and consideration needs to be made for the requirements of sharing the right-of-way with different transportation mode types.
- Some segments are narrow and may not be able to accommodate new facilities without modifications. The Lowell Line right-of-way, which is typically at least 80 feet wide, narrows to 50 feet in some sections between Harvard Avenue and Broadway and north of College Avenue. Additionally, the area north of the Mystic River contains at-grade highway-railroad crossings at Canal Street and High Streets, which will need to be addressed.
- There are 17 bridges on the New Hampshire Main Line and four bridges on the Fitchburg Line. At the time that these structures were originally built, these bridges were wide enough to accommodate up to four commuter rail tracks. However, over time several of these bridges have been rebuilt and the locations of the abutments were narrowed. Adjustments will be necessary to several of these bridges if additional modes of transportation will be provided within the right-of-way.
- A Community Path that is proposed along a portion of the Lowell Line. The project envisions the use of the abandoned segment of the Lexington & Arlington Railroad between Cedar and Lowell Streets. Heading southeast, it would extend along the MBTA's New Hampshire Main Line railroad right-of-way from Somerville Junction (near Lowell Street) to Washington Street. The alignment would then extend south to Lechmere area. Coordination with the community path is necessary to minimize impacts.
- There is currently inadequate layover space for expansion of transportation services. The ability to store and maintain vehicles at practical locations near the study area will be necessary for any expansion of service. As noted earlier in this chapter, the reconstruction of Lechmere Station presents an opportunity to increase the storage capacity in the area. However, even with the anticipated storage capacity expansion, additional layover space would be needed to expand Green Line service. Determining a location to provide sufficient storage and maintenance capacity for the service will be a necessary part of this study.

Even though these issues are constraints, design solutions can be examined to take advantage of the available right-of-way. The extent to which they are possibilities needs to be analyzed. For example, one of these constraints, the community path, could be an opportunity to improve pedestrian and bicycle access to the proposed transit systems and may help leverage multimodal/intermodal funding for transit development.

3.7.3 Environmental Considerations

Environmental considerations for the development of new transit facilities in the study area are both opportunities and constraints. There are several key environmental opportunities associated with the potential project. These include:

- Improved mobility to existing urban neighborhoods,
- Opportunity for Smart-Growth, Transit-Oriented Development,
- Reduced traffic congestion,
- Reduced automobile emissions, and
- Opportunity for cleanup and reuse of contaminated urban land.

Other potential negative environmental impacts that may require mitigation are:

- Additional noise in residential areas from construction and transit operations.
- Vibration caused by construction and transit operations.
- Wetland/Resource Area impacts associated with expanded infrastructure.
- Layover facilities.
- Transit vehicle emissions from fossil-fuel powered vehicles.
- Traffic impacts for in-road operations and at station sites.

3.8 Coordination with Other Projects

The communities in the study area are pursuing a number of transportation and development projects that are of importance to the project study area. Descriptions of the key features of these undertakings are provided as follows.

3.8.1 North Point Area

As noted previously, the North Point development promises to transform a formerly underutilized area of land straddling Cambridge, Somerville and Boston into a vital mixed-used, transit-oriented neighborhood. The groundbreaking for the North Point development occurred in March 2005, and marked the start of Phase 1 construction on two residential buildings totaling 329 condominiums, and half of the 10-acre Central Park green space. The North Point project will require continuing coordination among the private developer, the communities, and the MBTA, particularly as the Lechmere Station relocation is undertaken.

Adjacent to North Point, the Charles E. Smith residential development is a planned residential community. The project is proposed to redevelop and existing warehouse and retail operation into an apartment complex consisting of approximately 750 housing units in two buildings. A parking structure for approximately 900 spaces is also proposed.

3.8.2 Twin City Plaza Expansion

The proposed project will modernize the existing Star Market supermarket and add approximately 37,000 square feet to the existing store. The project will also provide general benefits to Twin City Plaza by improving site circulation for pedestrians and vehicles, increasing available parking by 100 spaces and improving landscaping.

3.8.3 Assembly Square

Immediately south of the Mystic River and directly west of the MBTA’s Orange Line and Commuter Rail right-of-way is the City of Somerville’s Assembly Square Planning District, a large triangular area bounded on the east by the MBTA right-of-way, on the north by the Mystic River, on the west by Route 28 and on the southwest by the I-93 on viaduct. The District has large retail facilities such as Home Depot, K-Mart and Circuit City as well as a Tage Hotel, a “99” Restaurant, a Loews Cinema complex, the Somerville District Court House and other retail, commercial and industrial facilities. Despite this mix of uses, the site appears underused and run down due to large vacant parcels, vast paved parking lots and vacant buildings.

The City has devoted extensive planning resources in developing a community development blueprint for Assembly Square that would accommodate more urban, transit-supportive uses and densities. Specific study efforts include:

1. *Assembly Square Planning Study: A Vision and Implementation Plan for the Future*, prepared by the Cecil Group, Inc. with others, October 2000;
2. *Assembly Square: Unifying Design Guidelines for the Public Realm* by Von Grossman & Company, March 2002
3. *Assembly Square Revitalization Plan: 2002 Major Plan Change*, prepared by OHCD, May 2002
4. *Assembly Square Transportation Plan*, prepared by Rizzo Associates, May 13, 2003

In addition to these study efforts, significant development proposals for the Assembly Square site have been submitted to the City:

- *Assembly Square: Proposal for the Redevelopment of Yard 21 and Neighboring Parcels, Design Concept*, submitted by The Sturtevant Partnership, August 15, 2001; and
- *IKEA at Assembly Square, A Mixed Use Development, Preliminary Master Plan, Planned Unit Development*, prepared by Arrowstreet and Vanasse Hangen Brustlin, Inc., submitted by IKEA Property, Inc., May 3, 2002

3.8.3.1 Yard 21

The Sturtevant Partnership Proposal proposes creation of a significant mixed-use district on Yard 21 and adjacent parcels. The Partnership controls approximately 10 acres adjacent to the MBTA right-of-way. The development program includes a mix of office (2,039,800 square feet), retail (327,800 square feet) and 860 residential units. Of specific interest is the Partnership's plan to physically connect the station access with the mixed-use development by means of a "Draw 7 Park Arcade." Equally of interest is its development density objective of generating sufficient ridership to justify a new Orange Line station.

Within the Assembly Square District, Yard 21 is directly west and adjacent to the MBTA ROW between Foley Street Extension on the north and Tenney Court Extension on the south. The Somerville Redevelopment Authority owns the 9.79-acre triangular shaped parcel, having acquired it in September 2000 from the MBTA for redevelopment purposes. The eastern portion of the parcel nearest to the MBTA ROW was a former railroad yard and is currently unused, overgrown with weeds and unsightly. The western portion of the Parcel is occupied by Central Steel, Spaulding Brick Company and Petrolane Company.

In 1997, Rizzo Associates, Inc. performed a Phase 1, Initial Site Investigation for the MBTA. Petroleum related compounds were detected in the soil and groundwater by the MA Department of Environmental Protection. The City has plans to redevelop the parcel and adjacent parcels into a mixed-use residential urban village centered on a new Orange Line Station. The Sturtevant Partnership has been designated by the City as developer of the parcel. Yard 21 is the most critical parcel for station siting purposes since access to the station will be through the parcel or adjacent to it.

3.8.3.2 Assembly Square Mall

The Assembly Square Mall is located on a 26.0-acre parcel of land. The redevelopment of this property will total nearly 690,000 gross square feet of buildings, including retail, office, and residential uses. The residential apartment building is reported to contain 184 studio, one-bedroom, and two-bedroom apartment units.

3.8.3.3 Stop & Shop Supermarket

A new Stop & Shop supermarket and an office building are being proposed for the former Somerville Lumber site and the adjacent Sherman Guber site on the southeast corner of the McGrath Highway/Mystic Avenue intersection. The site is approximately 7.1 acres. The proposed new facilities consist of a 73,133 square foot supermarket, an additional 7,340 square foot non-sales mezzanine area, and a 25,000 square foot office building, for a total of 105,473 square feet. The site will have 353 on-site parking spaces.

3.8.3.4 Winter Hill Yacht Club

Directly west of the MBTA ROW is a thin sliver of land owned by the MDC and occupied by the private Winter Hill Yacht Club. The Winter Hill site and the Draw 7 Park are linked by the two-lane roadway, described above, under the Dana Bridge.

3.8.3.5 IKEA Site

Directly west of the Winter Hill Parcel is a parcel owned by IKEA, the Swedish furniture retailer. The parcel is bounded by the Winter Hill parcel (MDC) and a thin sliver of riverfront land owned by the MDC. IKEA plans a major retail furniture store with underground parking. Additional planned uses include a riverside park, office space, and ground floor restaurants and retail. Currently the site is vacant. The development site is within walking distance of the potential site for the Orange Line Station.

3.8.4 Somerville Community Path

The City of Somerville is pursuing the construction of a bicycle / pedestrian facility linking the existing linear park at Davis Square to Lechmere. The project envisions the use of the abandoned segment of the Lexington & Arlington Railroad between Cedar and Lowell Streets. Heading southeast, it would extend along the MBTA's New Hampshire Main Line railroad right-of-way from Somerville Junction (near Lowell Street) to Washington Street. The alignment would then extend south to Lechmere area. The City completed a Feasibility Study in May 2001 and is presently undertaking initial design on the segment from Cedar Street to Central Street. Conceptual planning continues on the project.

Where the path is located at-grade along the MBTA's railroad right-of-way, the 12 foot wide path would have a three foot wide shoulder on each side. A fence and/or separating wall occupying a maximum width of two feet would be situated at the edge of the shoulder adjacent to the railroad right-of-way. Therefore, the total right-of-way requirement for the path would be 20 feet.

In addition to coordinating the physical arrangements of the project, there is also an opportunity to integrate the Community Path's neighborhood connections into the transit stations, particularly where the path will cross local streets at grade. The alignments under consideration for the Beyond Lechmere Project will be coordinated with the community path for compatibility.

3.8.5 Union Square Master Plan / Phase II

The City of Somerville is undertaking a multi-phase plan for the revitalization of Union Square. The Square is a commercial business district and an historic crossroads where several major city arterials converge. The Fitchburg Division tracks also pass just south of the Square. Rail service represented an important feature in the development of the various industrial activities that once dominated the southern portions of the Square. This industrial activity has declined, and some of these remaining activities are viewed as being incompatible with plans for commercial and residential development of the area.

Presently, Union Square is considered to be viable but not as flourishing or vital as it once was. The Square is not served by rapid transit or commuter rail lines, and it is thus perceived to be at a competitive disadvantage as compared to other nearby neighborhood, community and office commercial centers – such as Davis Square, Porter Square, Central Square, Kendall Square and Harvard Square – all of which are served by the Red Line. The Master Plan's statement of goals and objectives identifies a need to "*maintain an efficient and thorough system of transportation that balances public transportation, private and commercial vehicles, bicycles, and pedestrians that is consistent with Union Square's image as a commercial center.*"

Specific activities include:

- Work with the MBTA to establish the commuter rail stops to utilize the Fitchburg Line that passes through Union Square
- Work with the MBTA to establish a transit stop via the Green Line and the proposed Urban Ring
- Work with the MBTA to coordinate bus service within Union Square

One of the key elements in the revitalization plan is the need to locate all new major development sites within an easy walking distance (1,200 to 1,500 feet) of a proposed new multi-modal transit station planned along the Fitchburg Division right-of-way at the intersection of Prospect Street and Webster Avenue. The development in the vicinity of this transit facility may shift the "center of gravity' of Union Square slightly east towards Prospect Street, serving to enhance Prospect Street as the southern gateway to the Square.

3.8.6 Transportation Improvement Projects

The Transportation Improvement Program (TIP) identifies several transportation improvement projects currently proposed in the study area. Development of transit alternatives will need to be coordinated with these roadway efforts. Some of these projects include, but are not limited to, the following:

- ☐ Beacon Street - Reconstruction from Oxford Street to the Cambridge city line.

- I-93/Mystic Avenue Interchange – Construct a new underpass grade separating Route 28 northbound and converting the existing underpass to exclusive Route 28 southbound use.
- Somerville Avenue – Reconstruct Somerville Avenue from Union Square to the Cambridge city line and install visual enhancements along the south side of Somerville Avenue to School Street.
- Temple Street – Reconstruct Temple Street from Broadway to Mystic Avenue.
- Washington Street – Reconstruct Washington Street from the Boston city line to Route 28.

3.8.7 Planning Studies and Regulatory Initiatives

There are a number of planning studies that are underway or have been completed. The studies have identified areas for redevelopment and the types of redevelopment that should occur. In some cases transportation issues have also been addressed. Alternatives under consideration for transit improvements will need to be sensitive to the land use and potential improvements identified in these studies. Additionally, a brief listing of the studies and regulatory initiatives follows:

- **Urban Ring Project** – The Urban Ring Project, currently in the planning stages, consists of a three-phase, staged implementation of transit services in a circumferential corridor located approximately two miles outside of the center of downtown Boston. The project includes segments within the municipalities of Boston, Cambridge, Somerville, Brookline, Everett, Medford and Chelsea. The initial phase has consisted of implementation of three “Crosstown” bus routes by the MBTA, designated CT-1, CT-2 and CT-3. In late 2004 the MBTA completed the Draft Environmental Impact Report (DEIR) for Phase 2 of the project, which envisions the implementation of various Bus Rapid Transit (BRT) routes, expanded Crosstown bus services and improved intermodal transit connections. These services would provide connections from the existing Silver Line / Dudley Street terminal in Boston extending north and then east through the Longwood Medical Area, Kenmore Square, MIT, Kendall Square Lechmere, Union Square, Assembly Square, Orange Line stations between Community College and Wellington and east to Chelsea and Logan Airport. In addition to the proposed BRT routes, Phase 2 of the Urban Ring Project provides for new commuter rail stations at Union Square, Gilman Square and Sullivan Square. Phase 3 of the Urban Ring Project envisions conversion of some Phase 2 BRT routes and services to light rail and heavy rail rapid transit operations. Phase 3 has been developed as part of a Major Investment Study by the MBTA. However, an implementation schedule and plans for Phase 3 have yet to be formulated.

- **Assembly Square Orange Line Study** – Several alternative configurations have been developed for the proposed Assembly Square Orange Line Station which is a project under study by the City of Somerville. All of the alternatives seek to minimize any encroachment on the development parcels at the western side of the proposed station, while also seeking to minimize the need for re-alignment of the Orange Line tracks and the Haverhill/Reading Line commuter rail tracks situated east oft the Orange Line. The station configuration is ultimately intended to consist of three tracks serving two center platforms, thereby taking full advantage of the three-track Orange Line configuration at this location. Operational issues are also being addressed, notably the impact on existing Orange Line operations due to the implementation of a new station. Issues include impacts on travel times, headways, passenger capacity and the possible need for additional cars.

- **Eastern Cambridge Planning Study** – This study includes an analysis of existing conditions in Eastern Cambridge – historical context, urban design and open space, land use and zoning, real estate market for housing, office/R&D, retail and transportation. The study provides recommendations on zoning, land use, transportation, and other issues that aim to fulfill the vision for the future of East Cambridge.

- **Somerville Land Use/Zoning Policy -** The City of Somerville has a Zoning Ordinance that identifies the requirements for developments in the city. Elements to consider include dimensional requirements, off-street parking and loading, and Planned Unit Development (PUD). A special consideration in zoning is the proximity of a development to rapid transit or public parking. Reduced parking requirements may be made on developments that are located within 650 feet of municipal parking facilities or within 1000 feet of a rapid transit station.

- **Inner Belt Planning Study –** The City of Somerville hopes to see the Inner Belt District develop with full potential. The Inner Belt Planning Study outlines the existing conditions of the district. Future documents will examine the potential of the district, explore possible zoning changes that might help the district reach its potential, and examine public improvements that might be needs in the future to help the district grow.

- **McGrath Highway Corridor Study –** This study provides an overview of the existing conditions and current zoning of the areas adjacent to Route 28/McGrath Highway from Washington Street to the Cambridge city line, extending east to Merriam and Harding Streets and west to the railroad tracks bordering Brickbottom.

☐ **Tufts University Master Plan** - Tufts University is in the early stages of initiating a master plan for the area. The goal of the study is to conduct a full assessment of the present and future needs of Tufts University.

☐ **The Vision of Medford Square** - Coordinated by the City's Office of Community Development, this study examined economic opportunities associated with redevelopment particularly in the Medford Square area. Recommendations of the study will be considered for future comprehensive planning efforts for the entire City and to create a specific master plan for the Medford Square area.

☐ **Medford Open Space Plan** – Major goals of the Open Space Plan are to serve the specific recreation needs of Medford residents and to use the open space system to strengthen the community. The Medford Recovery Action Plan (RAP) is a supplement to the Medford Open Space Plan, which provides a framework for applying the Federal Urban Parks and Recreation Recovery Action Program to Medford's open space and recreation system.

3.8.8 Additional Private Developments

There are a number of private development initiatives that occur within the project study area. One example of this type of development is K.S.S. Realty Partners, Inc. plan for a residential development at 56 and 61 Clyde Street. The parcels are adjacent to the Lowell Line and the Lowell Street Bridge. Coordination with private developments along potential alternative alignments, such as this one, will need to be done throughout the project.

4

Identification and Evaluation of Alternatives – Tier 1

This chapter describes the initial set of alternatives that were identified to address the Purpose and Need of the Beyond Lechmere Northwest Corridor Study, and the methodology that was applied to screen these alternatives. The first section presents an overview of the two-tiered evaluation process for this study. Later sections summarize how the Tier 1 alternatives were developed; provide descriptions of these alternatives; describe the Tier 1 screening process; and summarize the findings of the Tier 1 screening.

4.1 Overview of Alternatives Identification and Evaluation Process

The methodology used to identify and screen the proposed alternatives was a two-tiered approach, designed to be consistent with MBTA and FTA guidance. The process began with an initial pool of alternatives identified from a review of existing conditions, plans and previous studies and designed to respond to the Purpose and Need for the project. Once the alternatives were selected, the Tier 1 screening was performed to evaluate the ability of the alternatives to meet broad transportation objectives established for the study, and to narrow the range of alternatives to a smaller set to be evaluated further in Tier 2. In the Tier 1 screening, the alternatives were evaluated against a set of mainly qualitative indicators. A numerical score was assigned to each alternative in each major evaluation category, allowing the alternatives to be ranked and compared to one another. From this screening process, a number of alternatives were selected to be carried forward into Tier 2.

In the Tier 2 alternatives identification and evaluation phase, the initial alternatives were further developed to provide a basis for more detailed evaluation and comparison. Conceptual operating plans, capital improvement requirements, capital costs, and operating & maintenance (O&M) costs were developed for each alternative. In addition, the Tier 2 alternatives were modeled by the Central Transportation Planning Staff (CTPS) using the statewide transportation model, providing quantitative results on the performance of each alternative in terms of ridership, highway/vehicular travel, air quality, environmental justice, and user benefit. The quantitative indicators developed in the Tier 2 screening process allow an analysis to be conducted of the merits of the Tier 2 alternatives and their ability to meet the Purpose and Need for the project.

The evaluation criteria for the Beyond Lechmere Northwest Corridor Study have been developed based on several sources:

- The Purpose and Need statement developed for the project;
- The Federal Transit Administration's New Starts project justification criteria;
- The MBTA Program for Mass Transportation (PMT) System Expansion and Service Enhancement Project Performance Measures; and
- EOTC's State Project Evaluation Criteria.

The evaluation criteria and methodology for this project have been developed with the objective of incorporating all the key indicators appropriate for a project of this type at this stage of project development. In some cases, evaluation criteria from the FTA or MBTA guidance documents have been consolidated or renamed, but their intent remains consistent with the source documents. The following sections describe the Tier 1 alternatives and the process for the Tier 1 screening.

4.2 Development of Tier 1 Alternatives

By investigating previous studies and working with the MBTA and the Advisory Group, a number of potential alternatives for transit improvements were identified within the Beyond Lechmere Northwest Corridor study area. Combinations of various mode types, including Green Line, Bus Rapid Transit (BRT) and Commuter Rail, were considered to provide additional transit service into study area neighborhoods. These combinations were grouped into a number of discrete alternatives to keep the screening and evaluation process manageable, while recognizing that other variations are possible. The overriding goal of all of the Tier 1 alternatives was to meet the Purpose and Need for the project.

4.3 Description of Tier 1 Alternatives

The following sections describe the Tier 1 alternatives that were considered, by mode type, for providing transit services in the study area. Graphics of the conceptual alignments are also provided.

4.3.1 Green Line Alternatives

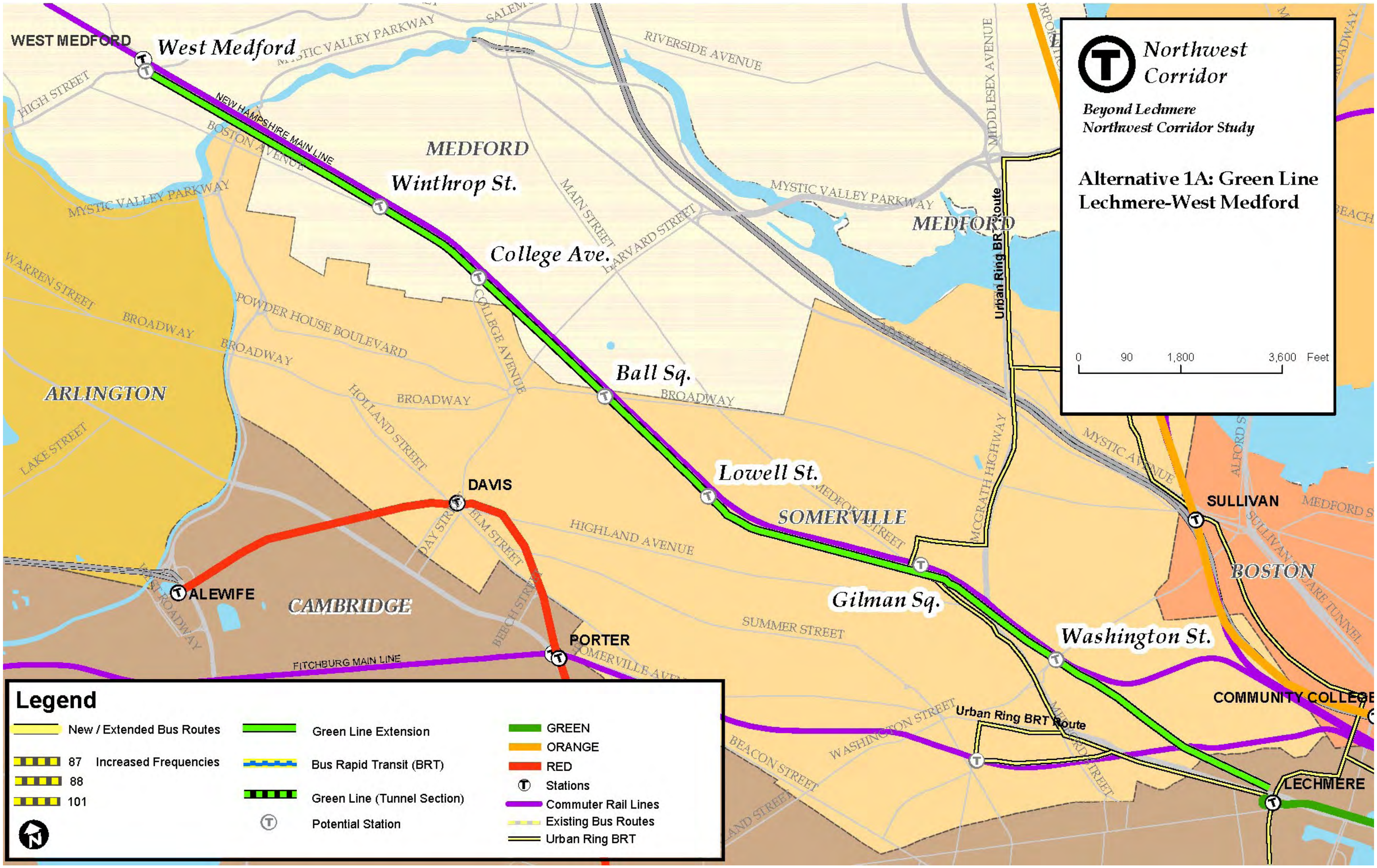
Four alternatives involving primarily Green Line service were developed for this evaluation. These alternatives are described briefly in the sections below, and depicted graphically in Figures 4-1 through 4-4.

Alternative 1A – Green Line Extension to West Medford: This alternative would provide an extension of the Green Line from Lechmere northwards along the MBTA's Lowell Line terminating in the vicinity of the existing West Medford commuter rail station.

Alternative 1B – Green Line Extension to West Medford via Union Square: This alternative would provide an extension of the Green Line from Lechmere westward to Union Square along the MBTA's Fitchburg Line into Union Square, then northwards via a new deep bore tunnel under Union Square and Prospect Hill, and join the Lowell Line right-of-way near School Street. The route would then continue northward to West Medford.

Alternative 1C – Green Line Extension to West Medford and to Union Square: This alternative would provide Green Line service to Union Square and West Medford via a two-branch operation. One branch would operate from Lechmere to West Medford along the Lowell Line as per Alternative 1A. The second branch would operate along the Fitchburg Line from Lechmere into a terminus at Union Square.

Alternative 1D – Green Line Extension to Union Square with Commuter Rail Station Stops to West Medford: This alternative would provide an extension of the Green Line from Lechmere west to Union Square along the MBTA's Fitchburg Line. This alternative would also construct two new commuter rail stations on the Lowell Line to West Medford. It should be noted that a third commuter rail station is proposed at Gilman Square as part of the MBTA's Urban Ring Project. Proposed commuter rail stations would be served by regularly scheduled Lowell Line trains.

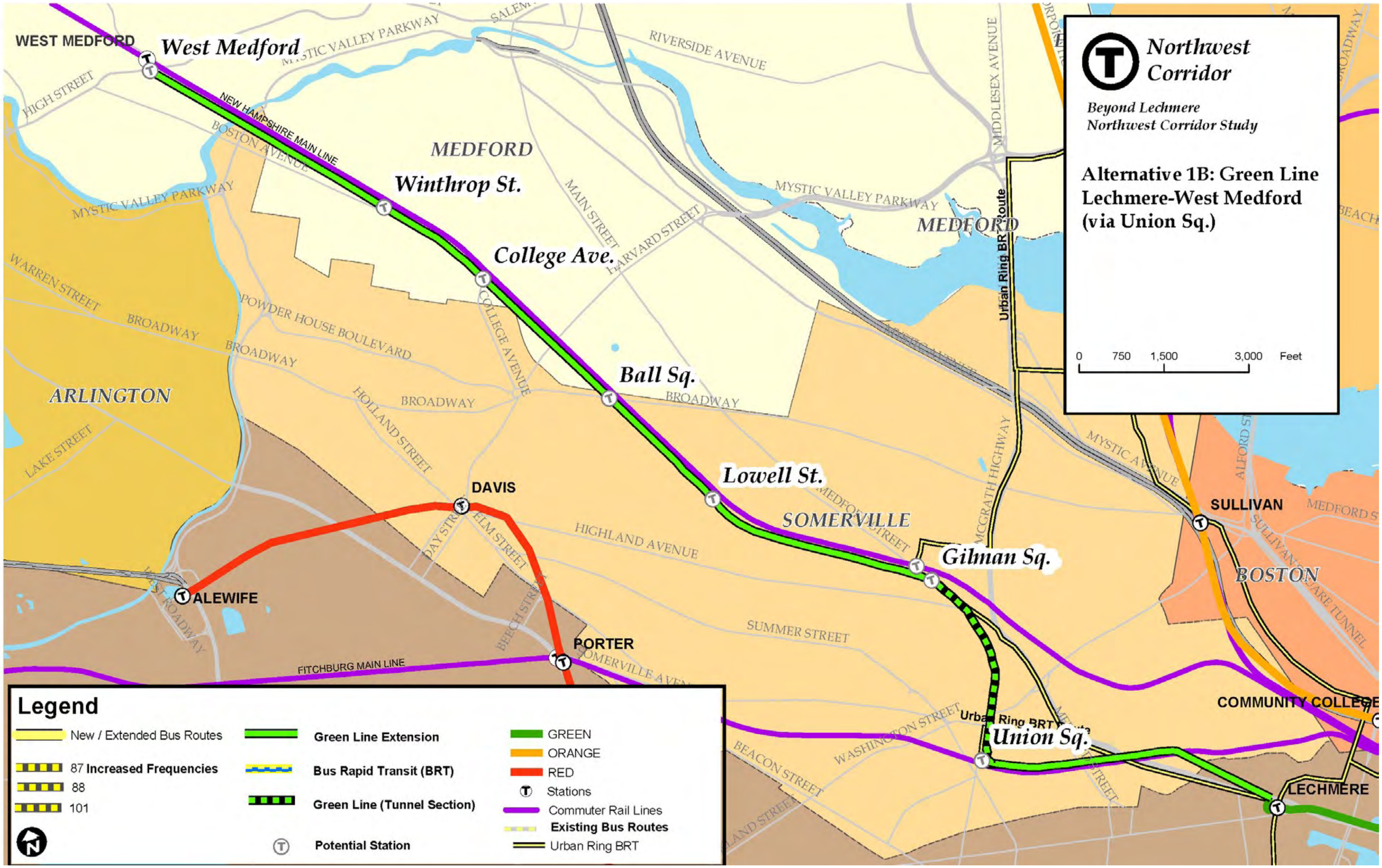


Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

Figure 4-1

Alternative 1A Conceptual Alignment



Beyond Lechmere Northwest Corridor Study

Figure 4-2

Alternative 1B Conceptual Alignment

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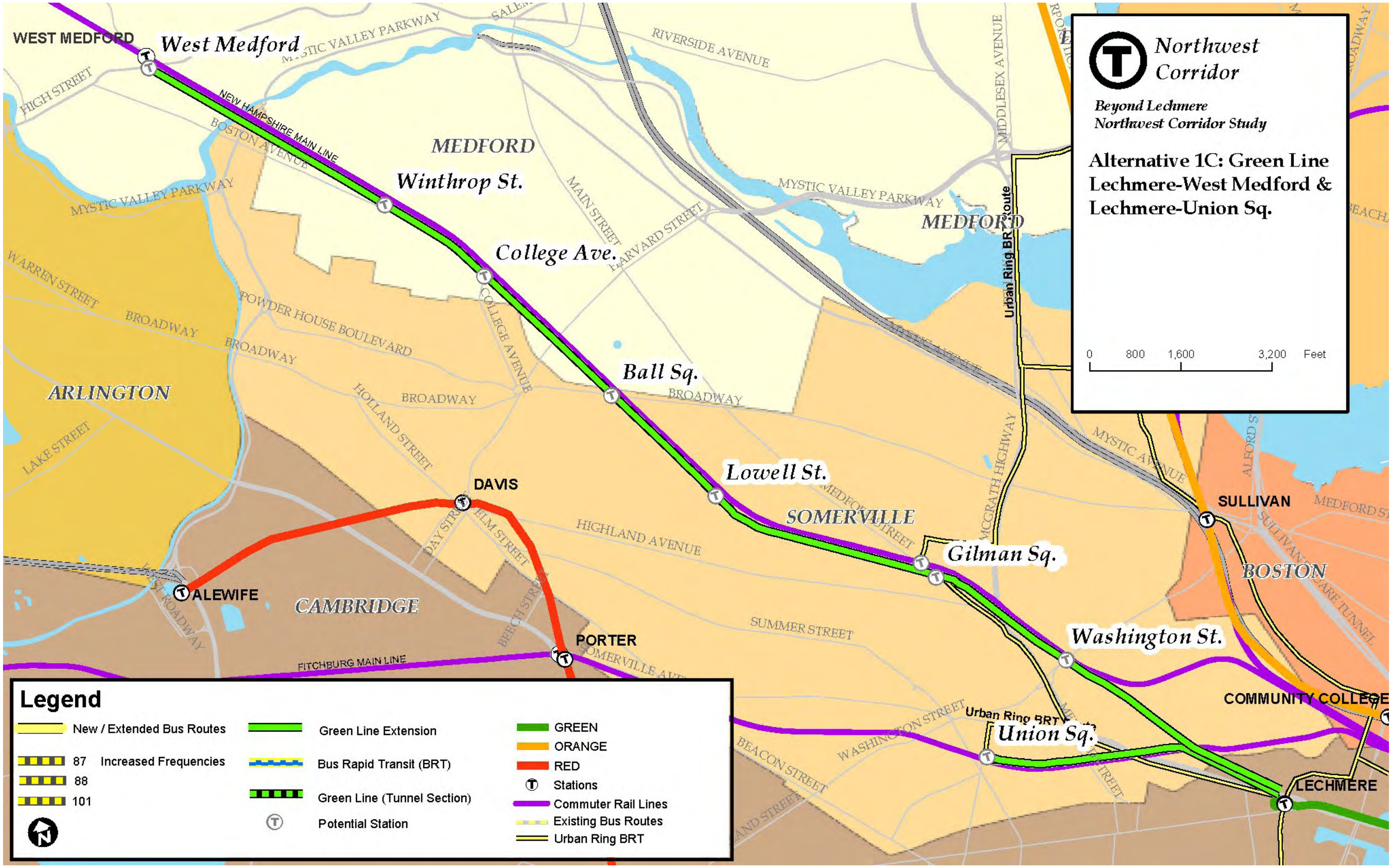
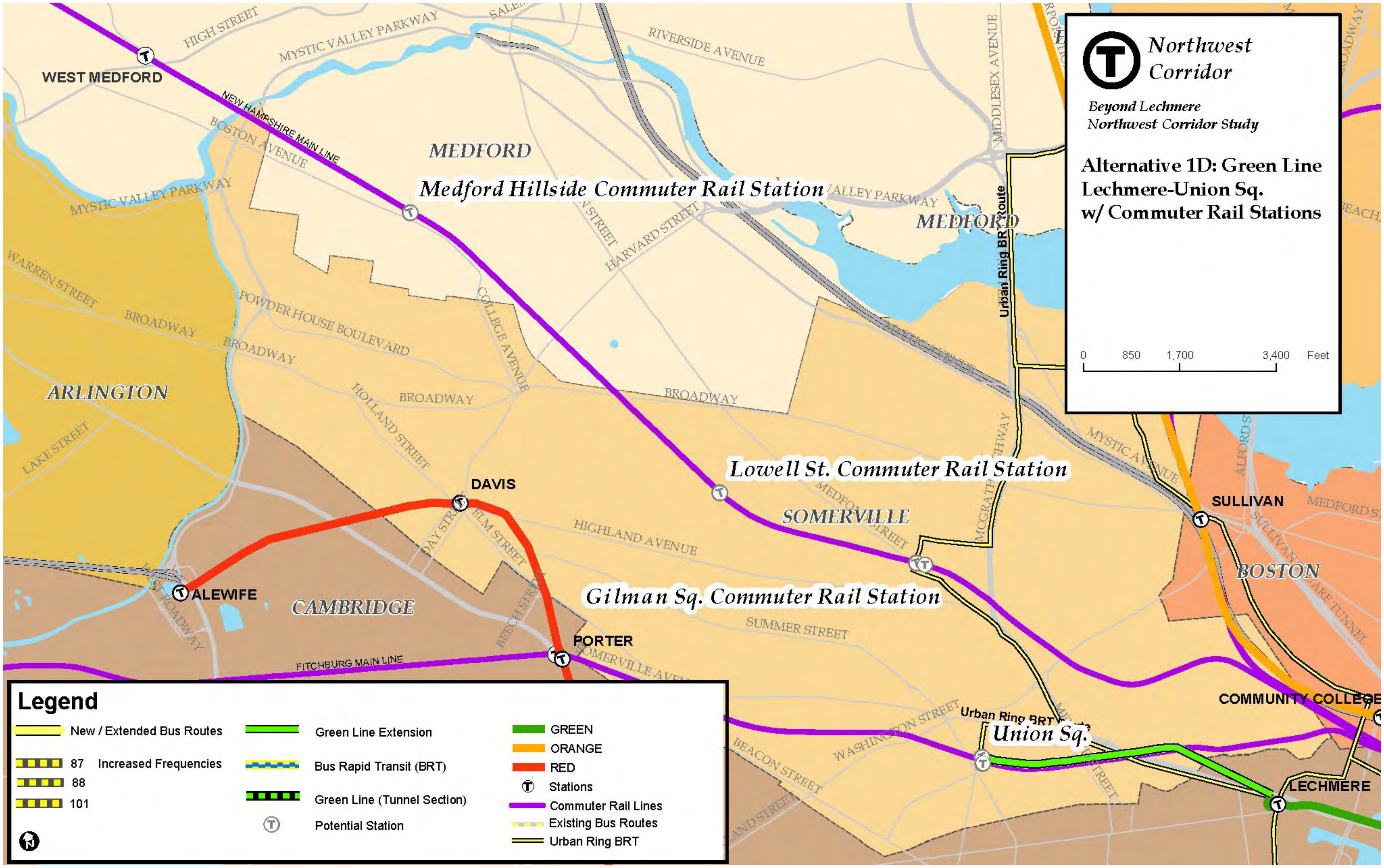


Beyond Lechmere Northwest Corridor Study

Figure 4-3

Alternative 1C Conceptual Alignment

Massachusetts Bay Transportation Authority



Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

Figure 4-4

Alternative 1D Conceptual Alignment

4.3.2 Bus Rapid Transit Alternatives

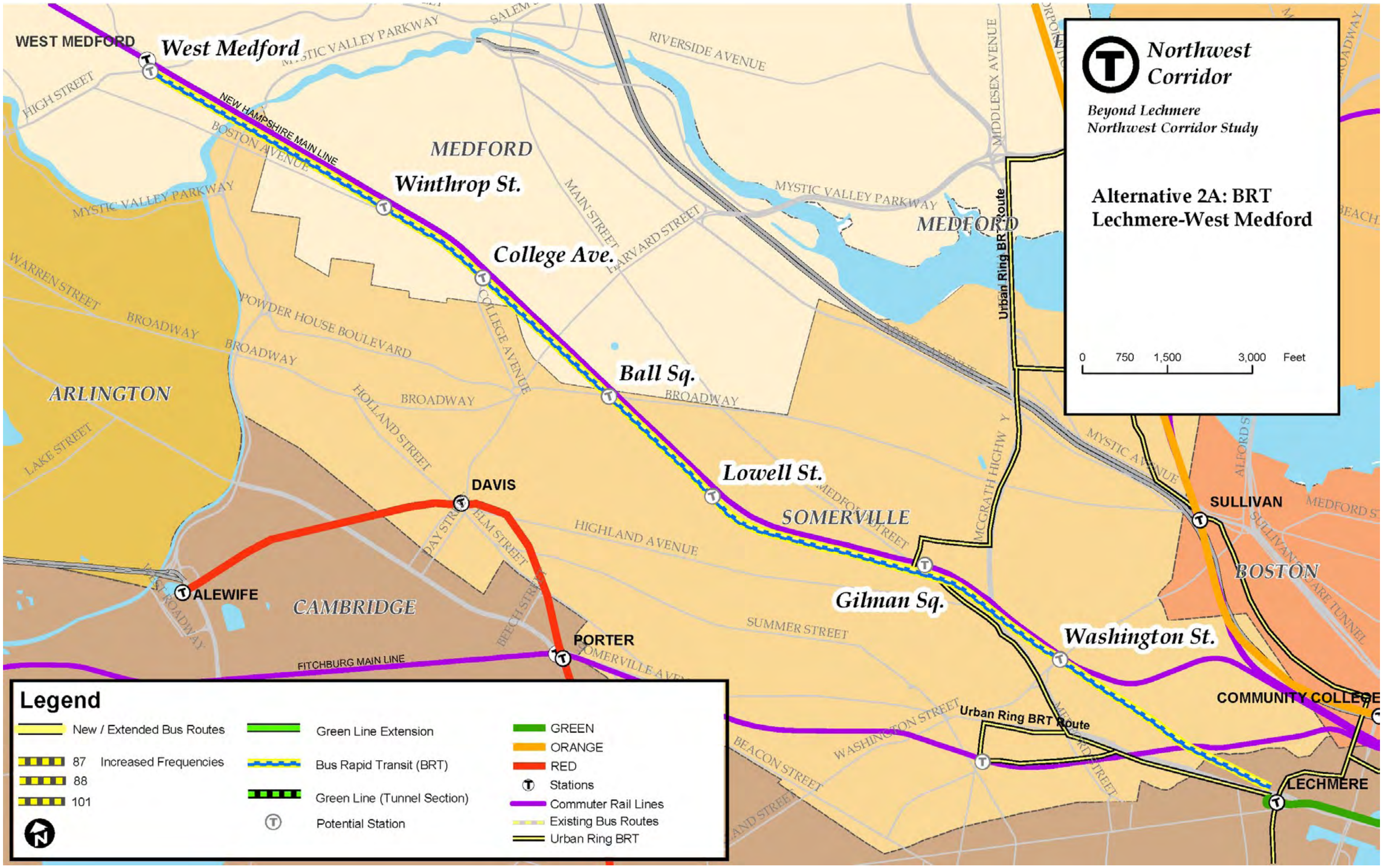
Four alternatives involving primarily Bus Rapid Transit (BRT) service were developed for this evaluation. These alternatives are described briefly in the sections below, and depicted graphically in Figures 4-5 through 4-8.

Alternative 2A– BRT Lechmere to West Medford: This alternative would replicate Alternative 1A, using high capacity buses operating on a two-lane paved roadway within the railroad corridor. The BRT mode could alleviate the Green Line related grade crossing concerns at West Medford by using public streets in this area.

Alternative 2B – BRT Lechmere to West Medford with Green Line to Union Square: This alternative would combine Alternative 2A and Alternative 1C. High capacity buses would operate on a new two-lane paved busway within the railroad corridor to West Medford. A Green Line segment would operate along the Fitchburg Line from Lechmere into a terminus at Union Square. A variant to this alternative would be to extend BRT to Union Square in place of the Green Line extension.

Alternative 2C – BRT Lechmere to West Medford via Union Square with Green Line to Yard 8: This alternative would provide BRT service from Lechmere to Union Square along the Fitchburg Line and Somerville Avenue, in a loop-type alignment. A new busway would be constructed between Somerville Avenue and the Fitchburg Line. Beyond Union Square, BRT would utilize public streets to reach the Lowell Line at Gilman Square. The route would then utilize the Lowell Line right-of-way north to West Medford. Green Line service would be extended north from Lechmere to "Yard 8," which is located just east of the Lowell Line between the Fitchburg Line and Washington Street. This would provide the opportunity for a station near Washington Street.

Alternative 2D – BRT Lechmere to Union Square with Commuter Rail Station Stops to North Station: This alternative would provide a BRT service from Lechmere to Union Square along the MBTA's Fitchburg Line. Additionally, this alternative would construct two new commuter rail station stops on the Lowell Line to West Medford. It should be noted that a third commuter rail station is proposed at Gilman Square as part of the MBTA's Urban Ring Project. Proposed commuter rail stations would be served by regularly scheduled Lowell Line trains.

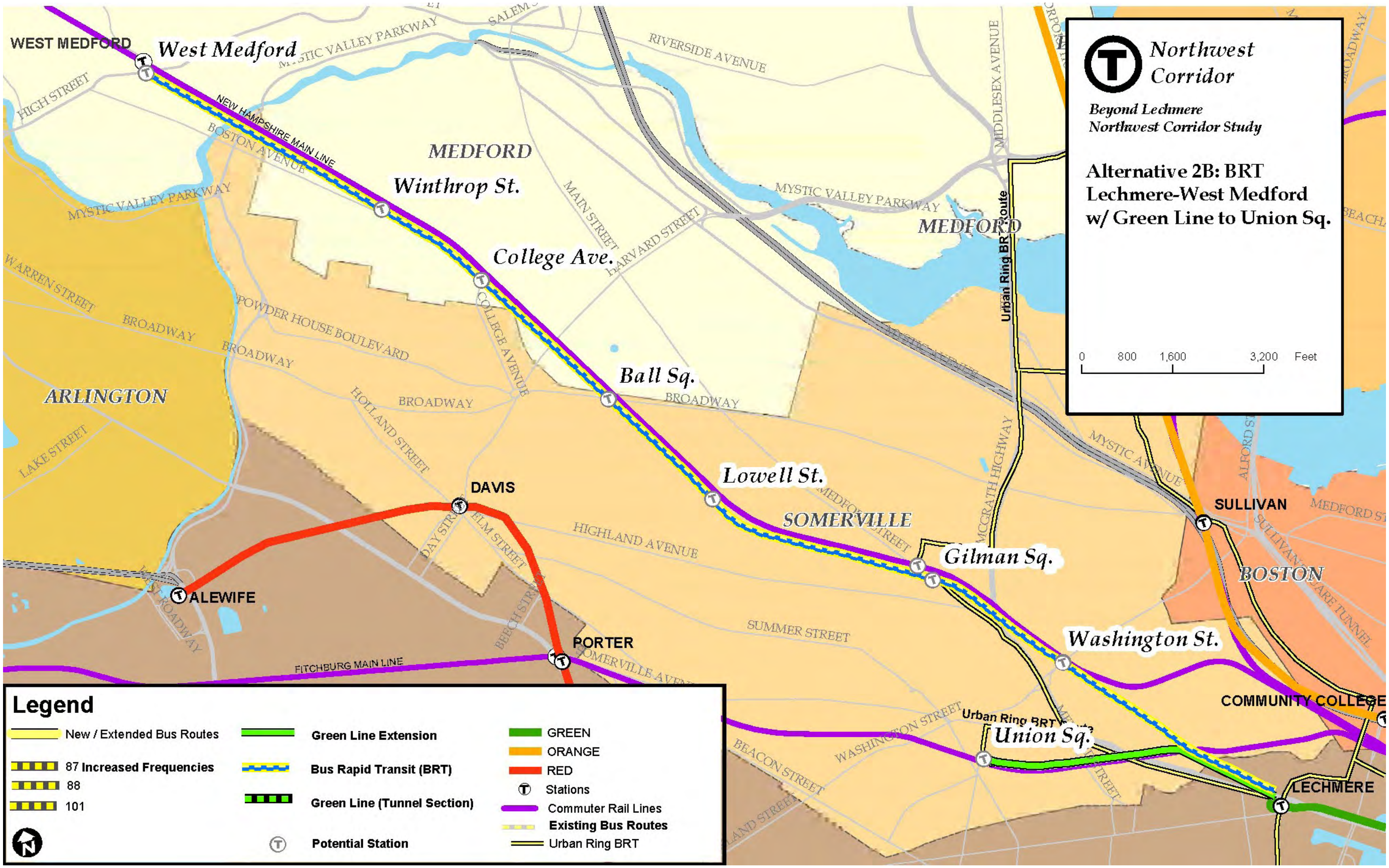


Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

Figure 4-5

Alternative 2A Conceptual Alignment



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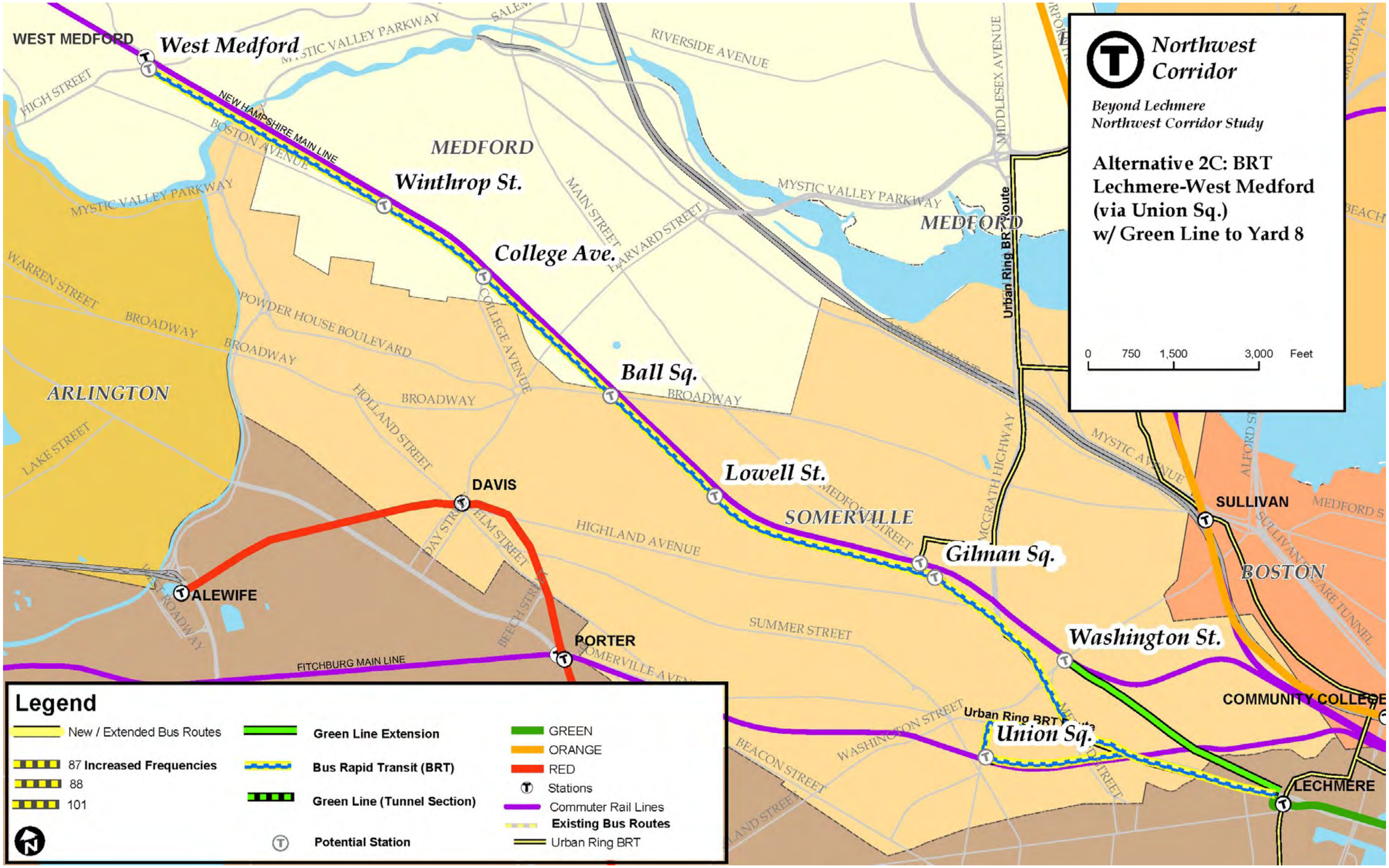
Beyond Lechmere Northwest Corridor Study

Figure 4-6

Alternative 2B Conceptual Alignment

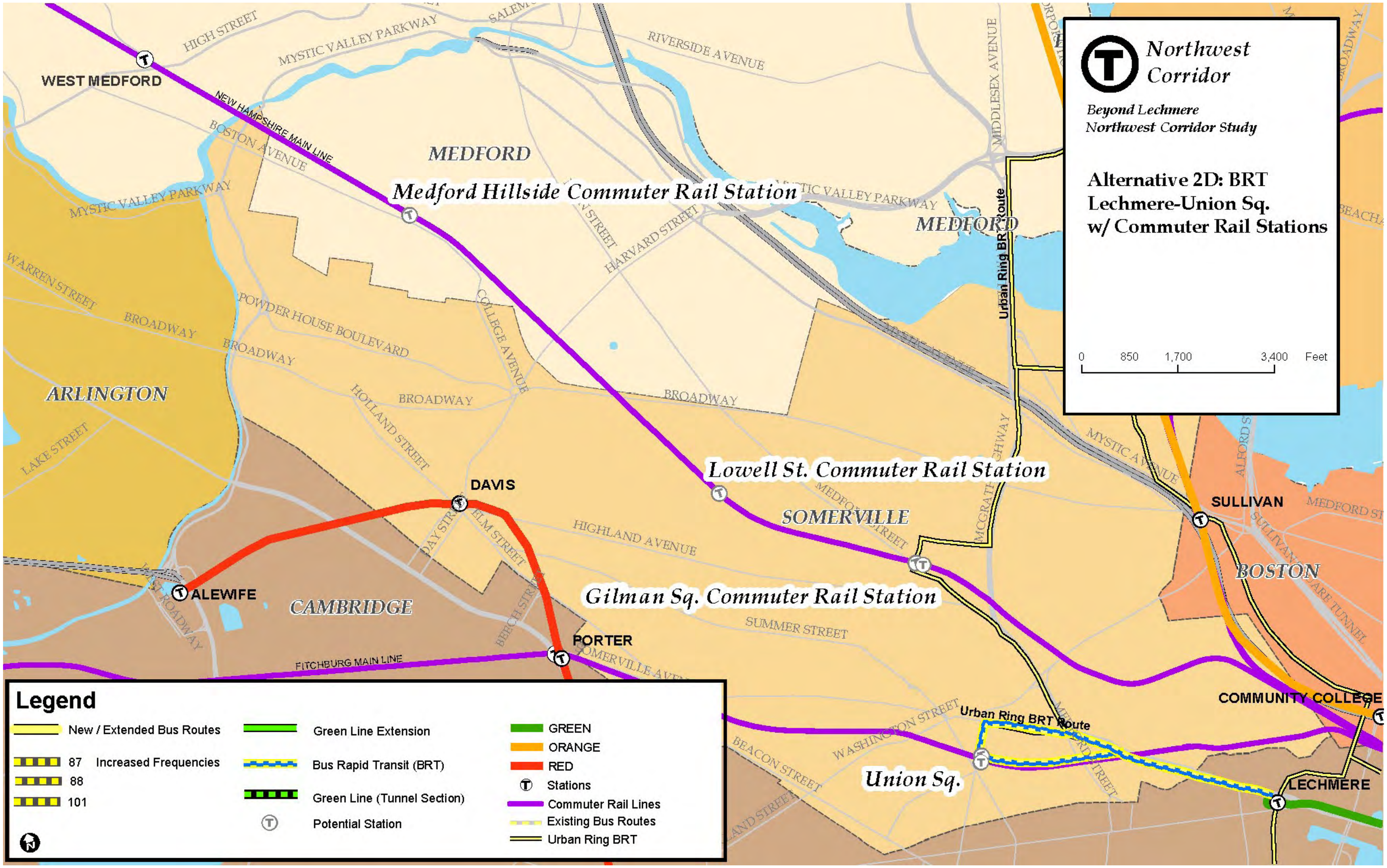


Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

Figure 4-7

Alternative 2C Conceptual Alignment



Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

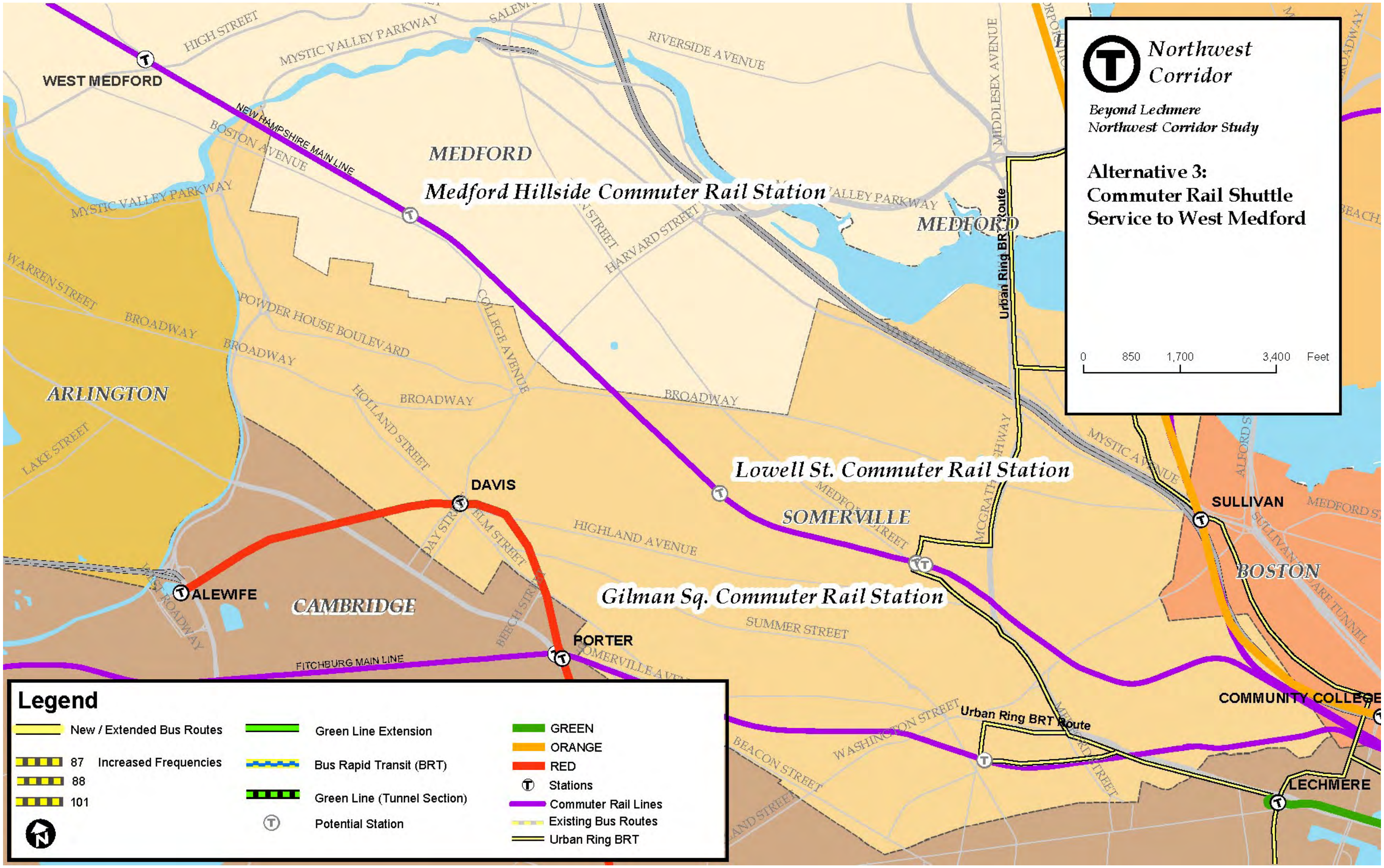
Figure 4-8

Alternative 2D Conceptual Alignment

4.3.3 Commuter Rail Alternative

One alternative involving primarily commuter rail service was developed for this evaluation. This alternative is described briefly in the section below, and depicted graphically in Figures 4-9.

Alternative 3 – Commuter Rail Shuttle Service to West Medford: This alternative would provide more frequent commuter rail service and additional stations on the Lowell Line through Somerville to West Medford. Operations would include the use of a shuttle train operating from North Station to West Medford. An additional track or a series of passing sidings may need to be constructed in the right-of-way to accommodate the service.



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Beyond Lechmere Northwest Corridor Study

Figure 4-9

Alternative 3 Conceptual Alignment

4.4 Tier 1 Evaluation and Screening

The purpose of the Tier 1 evaluation and screening of alternatives was to evaluate the ability of the alternatives to meet broad objectives that have been established for the project. The goal of the Tier 1 screening was to evaluate objectively the alternatives and identify those alternatives that should be evaluated in more detail.

It is important to note that the Tier 1 alternatives are preliminary and conceptual and that specific aspects such as routing (tunnels vs. roadway) and generalized station locations will be only be investigated at later stages of the Beyond Lechmere Northwest Corridor Study. The intent of the Tier 1 evaluation was to determine those alternative concepts that meet or exceed the project evaluation criteria, then narrow the initial broad range of alternatives to a reasonable number of feasible options that can be carried forward to a more detailed level of analysis.

4.4.1 Screening Process

At this level of screening, the analysis supporting the evaluation of the alternatives was primarily qualitative, answering questions such as how well the proposed alternative meets the objective, and how the proposed alternative compares to other alternatives.

Based on the existing conditions information compiled to date and the conceptual alignments for the alternatives (as presented in Figures 4-1 through 4-9), a broad-brush engineering assessment of each of the alternatives was performed. Each alternative was evaluated against the criteria detailed on the following page. Each proposed alternative was then rated on a scale of **+2 (meets objective/has a positive impact), to -2 (fails to meet objective/has a negative impact)** in each category. The ratings in the eight individual categories were summarized to produce a composite rating for each alternative.

4.4.2 Screening Criteria

The criteria used in the Tier 1 screening included the following general areas:

- **Environmental:** Does the proposed alternative improve the quality of the natural environment with a minimum of harmful impacts?
- **Regional Transit System Capacity:** Does the proposed alternative improve the capacity, reliability and quality of the regional transit system?
- **Access to Opportunity:** Does the proposed alternative improve access to opportunities such as employment, education, and health care for area residents?
- **Mobility/Connectivity:** Does the proposed alternative improve mobility and connectivity within the area's transportation system?
- **Compatibility with Land Use:** Does the proposed alternative fit within the context of the area's existing land use? Does the proposed alternative comply with economic development and Transit-Oriented Development plans for the area?
- **Environmental Justice:** Does the proposed alternative disproportionately burden or alleviate the burden on environmental justice populations?
- **Cost:** Does the proposed alternative provide transportation system user benefits at a reasonable capital and operating cost?
- **Constructability:** Can the proposed alternative be constructed within a reasonable time frame, with a minimum of impact on the existing transit system and existing land owners, and by utilizing existing infrastructure?

For each alternative, a table was developed showing the criteria; the individual ratings; explanations or identifications of key issues used in determining the ratings; and the sum total rating of the alternative. Descriptors such as "minor", "moderate" and "significant" have been used where appropriate in describing the impacts. Specific numbers or quantities were not applied to items such as air quality impacts. However, based on engineering judgment and a comparison of alternatives to each other and to existing conditions, general magnitudes of impacts such as "major" or "minor" were applied where appropriate. In Tier 2, quantifiable elements such as ridership, air quality and cost impacts were developed and examined in more detail for the selected alternatives; this process is described in Chapter 5. Table 4-1 presents a summary of the Tier 1 screening, while the detailed matrices are provided in Appendix A.

Table 4-1 – Summary of Tier 1 Screening

		Tier 1 Evaluation Criteria								
Alternative No.	**Description**	**Environmental**	**Regional Transit System Capacity**	**Access to Opportunity**	**Mobility/Connectivity**	**Comptability with Land Use/Economic Development**	**Environmental Justice**	**Cost**	**Constructability**	**Totals**
Green Line Alternatives										
1A	Green Line Extension to West Medford	1	1	2	1	1	2	0	1	**9**
1B	Green Line Extension to West Medford via Union Square	-1	1	2	2	2	1	-2	-2	**3**
1C	Green Line Extension to West Medford and to Union Square	1	0	2	2	2	2	0	1	**10**
1D	Green Line to Union Square with Commuter Rail Station Stops to West Medford	1	0	2	1	2	1	1	-2	**6**
Bus Rapid Transit Alternatives										
2A	BRT Lechmere to West Medford	0	0	2	0	1	1	1	1	**6**
2B	BRT Lechmere to West Medford with Green Line to Union Square	0	1	2	1	2	2	1	1	**10**
2C	BRT Lechmere to West Medford (via Union Square) with Green Line to Yard 8	0	1	2	0	1	0	1	1	**6**
2D	BRT Lechmere to Union Square with Commuter Rail Station Stops to West Medford	0	-1	1	1	1	1	2	-2	**3**
Commuter Rail Alternatives										
3	Commuter Rail Shuttle Service with Third Track to West Medford	1	1	1	1	1	1	1	2	**9**

4.5 Tier 1 Findings

Based on the Tier 1 screening results summarized in Table 4-1, the highest-rated alternatives were identified to proceed to Tier 2, and the lowest-rated alternatives were eliminated from further study. Based on the Tier 1 screening, the following alternatives were indicated to be the top rated alternatives:

- Alternative 1A – Green Line Extension to West Medford
- Alternative 1C – Green Line Extension to West Medford and to Union Square
- Alternative 2B – BRT to West Medford with Green Line to Union Square
- Alternative 3 – Commuter Rail Shuttle Service to West Medford

These alternatives were developed further in the Tier 2 alternatives identification and screening process, which is described in the next chapter.

5

Identification and Evaluation of Alternatives – Tier 2

This chapter describes the set of Tier 2 alternatives that were identified to address the Purpose and Need of the Beyond Lechmere Northwest Corridor Study, and the methodology that was applied to evaluate these alternatives. The first section summarizes how the Tier 2 alternatives were developed. Later sections offer descriptions of these alternatives; summarize the modeling of the alternatives performed by the Central Transportation Planning Staff (CTPS); describe the Tier 2 evaluation process; and summarize the findings of the evaluation.

5.1 Development of Tier 2 Alternatives

This section describes how the Tier 2 alternatives were identified, then briefly summarizes how they were developed. This includes a brief description of the methodology used in developing conceptual alignments, operating plans, capital investment requirements, conceptual capital costs, and conceptual operating & maintenance (O&M) costs.

5.1.1 Identification of Tier 2 Alternatives

As described at the start of Chapter 4, a two-tiered approach was used in the identification and evaluation of alternatives for the Beyond Lechmere Northwest Corridor Study. In Tier 1, an initial set of alternatives were developed by investigating previous studies and working with the MBTA and the Advisory Group. These Tier 1 alternatives were evaluated on their ability to meet the project objectives based on a number of criteria using qualitative analysis. From this screening process, the initial range of alternatives was narrowed to a smaller number of feasible options to be developed at a more detailed level of analysis.

Based on the Tier 1 screening summary, four alternatives emerged as the top-rated alternatives: Alternatives 1A, 1C, 2B, and 3. The set of Tier 2 alternatives began with these four alternatives. In addition to these four, a fifth alternative, which would extend commuter rail shuttle service beyond West Medford to the Anderson Regional Transportation Center (RTC) in Woburn, was added based on stakeholder input. To distinguish the two commuter rail alternatives, the original Tier 1 commuter rail alternative was renamed Alternative 3A, and the new alternative to the Anderson RTC was named Alternative 3B.

In addition to these five Build alternatives, two other alternatives were identified for the purpose of evaluation and comparison. A Transportation System Management (TSM) alternative was developed, the intent of which was to address, at least in part, the project Purpose and Need with relatively low-cost changes to the existing transportation system. Like the Build alternatives, this TSM alternative was developed at a conceptual level, and will be further developed should this project advance through the Federal environmental review process. The TSM Alternative was named Alternative 4 for the purpose of the Tier 2 evaluation.

To support the process of modeling the ridership, user benefit, air quality, and environmental justice impacts of the Build and TSM Alternatives, a No-Build Alternative was also developed. The No-Build Alternative is based on the projects in the Regional Transportation Plan 2004-2025 of the Boston MPO, with transit improvements in the Northwest Corridor beyond Lechmere removed. This No-Build Alternative was used as the basis against which the Build and TSM alternatives were compared in all areas except user benefit. For the user benefit comparison, the Build Alternatives were compared to the TSM Alternative.

The following is a list of the Tier 2 alternatives that were evaluated:

- Alternative 1A: Green Line Extension to West Medford
- Alternative 1C: Green Line Extension to West Medford and Union Square
- Alternative 2B: BRT to West Medford, Green Line to Union Square
- Alternative 3A: Commuter Rail Shuttle Service to West Medford
- Alternative 3B: Commuter Rail Shuttle Service to Anderson RTC
- Alternative 4: Transportation System Management Alternative
- No-Build Alternative

The characteristics of these Tier 2 alternatives are described in Section 5.2 of this chapter.

5.1.2 Methodology for Tier 2 Alternatives Development

The Tier 2 alternatives were developed in five main areas: conceptual alignments, operating plans, capital investment requirements, conceptual capital costs, and conceptual O&M costs. The methodology for alternative development used in each area is briefly described in the following sections.

5.1.2.1 Conceptual Alignments

The conceptual alignments for the Tier 2 alternatives were developed to a level slightly more refined than in the Tier 1 alternatives. Conceptual station locations were identified based on a review of existing activity centers, giving consideration to general minimum station spacing requirements for each transit mode. Broad assumptions were made about whether the alignment would be at-grade or below-grade, and whether the vehicles would travel in dedicated corridors or in mixed traffic. General assumptions were made about the size of required support facilities and infrastructure (such as maintenance/layover facilities) but specific locations for such facilities were not identified.

It is important to note that the conceptual alignments in Tier 2 were explored only to a level sufficient to develop preliminary operating plans and estimate conceptual costs. No engineering drawings, surveys, identification of specific station or support facility locations, or assessments of right-of-way requirements were undertaken; this work will be performed in later study stages for alternative(s) selected for further consideration.

5.1.2.2 Operating Plans

Operating plans for the alternatives were developed to allow the identification of vehicle requirements; estimation of capital costs; and modeling of ridership, user benefit, air quality, and environmental justice impacts. The conceptual operating plans for the Build alternatives consisted of five key items: station locations; planned headways; travel times between stations; station dwell times; and the turnaround time at the end of the corridor.

It is important to note that the operating plans for each alternative were developed to offer a fair comparison between alternatives to the greatest extent possible. For instance, in both Alternative 1A and 1C, the existing Green Line service at Lechmere was extended northwest along the proposed alignments. In Alternative 1A, this extension resulted in headways equal to those at Lechmere Station, while in Alternative 1C this resulted in longer headways due to the split to service to two destinations. In the commuter rail alternatives, headways were assumed to be 15 minutes, the shortest headway possible given the time required to turn around a train at North Station. The Build alternatives (Alternatives 1A, 1C, 2B, 3A and 3B) also assumed no change in existing bus service.

5.1.2.3 Capital Improvements

Capital improvement requirements were identified for each of the Build alternatives and for the TSM alternatives based on the conceptual alignments and operating plans. Capital improvements include infrastructure items (such as track installation, bridge construction, or signal system installation) and vehicle acquisition.

Infrastructure requirements were identified at a conceptual level based on the conceptual alignments. For instance, the number of bridges along a specific segment that would need to be replaced was identified based on assumptions about the width of the proposed alignment and existing bridge widths. Similarly, quantities of track, guideway surface, or signal system to be installed were estimated based on approximate lengths of segments in each alternative.

Vehicle requirements were estimated based on the conceptual operating plans developed for each alternative. The number of vehicles is generally a function of the length of the corridor, planned headways, the average speed of the vehicle, station dwell times, and turnaround times at the end of the corridor. Vehicle requirements are estimated based on these factors and include active vehicles in service and an allowance for spares.

5.1.2.4 Conceptual Capital Costs

Conceptual capital costs were estimated for the five Build alternatives and one TSM alternative considered in the Tier 2 alternatives screening process. These capital cost estimates were developed based on the conceptual alignments and operating plans described previously, in accordance with FTA guidelines for the preparation of capital cost estimates. The items in the cost estimates are grouped into ten cost categories which are consistent with the FTA's Standard Cost Categories (SCCs) for Major Capital Projects. These categories are:

- Guideway and Track Elements
- Stations, Stops, Terminals, Intermodals
- Support Facilities: Yards, Shops, Administrative Buildings
- Sitework and Special Conditions
- Systems
- ROW, Land, Existing Improvements
- Vehicles
- Professional Services
- Unallocated Contingency
- Finance Charges

It should be noted that these estimates are based on a conceptual level design. Since no design detail has been completed at this stage, a 50% contingency cost has been added to the infrastructure costs. This contingency has been applied to address those areas or items which may not be possible to identify at this level of design. As the design process progresses, the contingency percent will be reduced for each phase, ultimately reaching zero when the plans and specifications are at the 100% design phase. The conceptual estimate also includes additional costs associated with the implementation of the project including project administration, engineering, real estate acquisition, and construction mitigation.

Unit costs used in the capital cost estimates are based on averages of costs for similar recent construction in the southern New England region. In instances where similar improvements have not been purchased or constructed in the past five years, such as Green Line vehicles, the costs of older purchases have been used and then escalated to account for inflation.

A list of assumptions included as part of the conceptual capital cost estimates are detailed below. As with the contingency percentage, the number of assumptions will be reduced and/or modified as the design details progress during future phases. The assumptions used in the development of the capital cost estimates are as follows:

General Assumptions

1. All capital cost estimates have been developed using current year (2005) dollars.

Guideway and Track Elements

1. In locations where commuter rail shares the right-of-way with light rail or bus, a crash wall will be constructed to provide separation for safety purposes, as specified by the MBTA and all applicable regulations.
2. The existing commuter rail tracks along the New Hampshire Main Line (Lowell Line) will be relocated to one side of the right-of-way to make room for the guideways for Alternatives 1A, 1C and 2B.
3. Light rail transit guideway improvements will include construction of two new ballasted tracks. Track interlockings will be constructed at regular intervals.
4. BRT guideway improvements will include a 24-foot wide two-lane busway with four foot shoulders. Bus pull-out areas will be constructed at regular intervals.
5. Commuter rail guideway improvements will include construction of a single new ballasted track. Track interlockings will be constructed at regular intervals.
6. The BRT guideway will require lighting because it is assumed to be unsignalized between stations, and will require a drainage system because it has an impervious surface.
7. It is assumed that some of the existing bridges along the Lowell and Fitchburg Lines would need to be reconstructed to accommodate the new track or guideway. Specific assumptions about which bridges

would need to be reconstructed in each alternative are noted later in this chapter.

8. For the purpose of the conceptual capital cost estimates, it is assumed that no work will be required inbound from Lechmere Station to accommodate the length and volume of trains planned to operate along the line.

Stations, Stops, Terminals, and Intermodal Facilities

1. Proposed new stations will be unstaffed stations where fares are paid onboard.
2. Light rail stations will include a 225-foot by 24-foot center island platform that can accommodate three-car trains with partial canopy. Commuter rail stations will include an 800-foot by 24-foot center island platform, which can accommodate a nine-car train consist. BRT stations will be configured with either a 150-foot by 20-foot center island platform or two 150-foot by 20-foot staggered side platforms, each of which can accommodate two buses. Further information about BRT station configurations is provided in Section 5.2.3.3 of this chapter.
3. In most cases, street access to platforms will be provided from existing nearby overhead bridges via a stairway and accessible switchback ramp. Exceptions may be made at the West Medford Station, which would potentially be located between two grade crossings at High Street and Canal Street; and the Washington Street Station in Somerville, where the existing rail corridor crosses over the roadway.

Support Facilities: Yards, Shops, and Administrative Buildings

1. The specific location and layout of maintenance facilities and yards will be developed during later phases of this project. The capital cost estimates include an order-of-magnitude cost to construct a facility for mode(s) requiring additional storage and maintenance capacity.
2. All alternatives that include light rail transit (1A, 1C and 2B) include costs for the construction of a light rail light maintenance facility and yard of the size necessary to accommodate the existing and projected fleet to be serviced. It is assumed for the purpose of the conceptual capital cost estimates that the layover/maintenance facility will be located at “Yard 8,” although other locations could be considered in later phases of this project.
3. For the purpose of the capital cost estimates, it is assumed that a full maintenance facility would be constructed for the BRT fleet. The costs for the construction of a BRT maintenance facility of the size necessary to accommodate the projected fleet to be serviced. It is assumed that the

maintenance facility will be located at Wellington, although other locations could be considered.

4. It is assumed that layover and maintenance of the commuter rail vehicles will be provided at the MBTA's existing Commuter Rail Maintenance Facility (CRMF). Therefore, no maintenance facility capital costs for commuter rail alternatives are anticipated.

Sitework and Special Conditions

1. Site work costs include project-wide clearing, demolition and fine grading.
2. It is assumed that there are no major utilities that need to be modified or relocated.
3. It is assumed that there are not any underground storage tanks, fuel tanks or other hazardous materials that would be impacted by the project improvements.

Systems

1. Light rail transit systems will include the signals and communications system and the traction power system, including catenary and substations). Track interlockings will be constructed at regular intervals.
2. BRT systems will be limited to signals and communications at the station areas.
3. Commuter rail system improvements associated with Alternative 3 will include modifications to the existing wayside signal system to accommodate the third track. Track interlockings will be constructed at regular intervals.

ROW, Land, and Existing Improvements

1. For the conceptual-level cost estimates, this category contains two main items: real estate acquisition and construction mitigation.
2. Real estate acquisition includes land acquisition in fee, as well as temporary and permanent easements required to construct the project. Some right-of-way acquisition may be necessary in constrained areas of the corridor, such as along the Fitchburg Line between Lechmere and Union Square and along portions of the Lowell Line north of College Avenue. Land acquisition may also be necessary for the construction of a vehicle maintenance and storage facility. For the purpose of the conceptual capital cost estimates, a placeholder cost for real estate

acquisition has been included. This cost will be refined as the design progresses.

3. Construction mitigation represents the cost of measures to mitigate the construction impacts of the project. These costs are currently estimated as a percentage of the total infrastructure costs (2%) and will be further refined as the design progresses and mitigation measures are defined.

Vehicles

1. The vehicle fleet size for each mode and alternative has been calculated to accommodate the peak-period vehicle requirements with a 15% spare ratio.
2. Light rail transit vehicles are assumed to be low-floor vehicles similar to those presently in service on the Green Line.
3. BRT vehicles are assumed to be low-floor, 60-foot articulated Emissions Controlled Diesel (ECD) buses.
4. Commuter rail coaches (bi-level) and locomotives are assumed to be similar to those currently in service on the MBTA's commuter rail system.
5. A 20% contingency has been included in the cost of the vehicles to account for the changing marketplace costs of vehicles.

Professional Services

1. For the conceptual-level cost estimates, this category includes three main items: engineering services, project administration, and construction management.
2. Engineering costs include fees for preliminary and final engineering to prepare the project plans, specifications and estimates, and for support through the construction of the project. Engineering costs are estimated to be 10% of the total construction cost.
3. Project Administration represents the cost that the MBTA incurs for the implementation, management and day-to-day oversight of the project during the design and construction phases. Project Administration is estimated to be 8.5% of the total construction cost.
4. Construction Management represents the cost that is incurred to oversee and coordinate the construction phase of the project. Construction Management is estimated to be 10% of the total construction cost.

Unallocated Contingency

1. A contingency factor of 50% has been added to all capital items, excluding vehicles. This contingency is applied to account for conditions or circumstances that can not be known or are not evident at this conceptual level of design.

5.1.2.5 Conceptual Operating & Maintenance Costs

Conceptual O&M costs were estimated for the five Build alternatives and one TSM alternative considered in the Tier 2 alternatives screening process. Operating and maintenance costs are the expenses incurred to provide day-to-day operations and maintenance of the transit system. Labor and direct expenses are two main components of O&M costs. Labor expenses include salaries of management, administrative, operations, and maintenance staff. The staffing level required for a project is based on the fleet size and the hours of operation for the proposed service. Direct expenses include costs for management/administration, operations, equipment and ROW maintenance, power/utilities, spares/consumables, cleaning/facilities maintenance and other/contingencies.

Major categories of O&M costs and their associated items and staff categories are listed below. These general O&M categories and descriptions are used as a guide in the development of operating and maintenance costs for transit projects. Not all categories will be applied to all transit services. Cost categories will be applied as necessary, depending on the scale and complexity of the system and the type of transit technology.

- **Management/Administration** – Includes O&M manager, ground transportation coordinator, transportation administrative assistance and department secretary.
- **Operations** – Includes transportation operations manager, central control supervisor, controller/assistant controller, operators supervisors, operators/drivers and passenger service agents/rovers.
- **Equipment and ROW Maintenance** – Includes maintenance manager, maintenance control supervisor, maintenance controller, secretary/clerk, mechanical maintenance supervisor, mechanical technicians, train hostlers, wayside maintenance supervisor, wayside technicians, electronics maintenance supervisor, electronics technicians, storekeeper/parts clerk.
- **Power/Utilities** – Includes propulsion power, station power, maintenance facility power and other power.
- **Spares/Consumables** – Includes spares and consumables, tool and equipment replacement, etc.

- **Cleaning and Facilities Maintenance** – Includes station maintenance, maintenance facility maintenance, CCTV/PA maintenance, radio maintenance, tools and test equipment maintenance, tires/wheels maintenance and vehicle cleaning.
- **Other** – Includes office equipment, supplies, insurance, training, uniforms, administration and support, fare collection processing and support and contract services/consultants.

Based on these cost categories and historical costs, the MBTA has developed a cost model for the estimation of operating and maintenance costs. The MBTA O&M cost model is based on a disaggregate and resource build-up approach, as suggested by the Federal Transit Administration. Resource build-up models compute costs by estimating what quantities of the costs listed above would be required to provide a given level of service. Each line item cost is determined according to the existing quantity of service supplied among other system characteristics. Each line item is classified as fixed and/or variable, with variable expenses assumed to drive the incremental service costs for each service alternative. The O&M cost model is calibrated based on costs from the levels of service in the MBTA FY2004 operating budget and the January 2004 staffing levels. The following is a summary of each cost basis from the MBTA's O&M cost model that was used in developing the conceptual O&M cost estimates for this study:

- The costs for standard bus services are estimated as follows: $37,200 per peak period bus, $36.20 per revenue vehicle hour, $1.07 per revenue vehicle mile, and $0.05 per rider.
- The costs for Green Line services are estimated as follows: $74,000 per surface station, $44,270 per peak period train, $40.90 per revenue vehicle hour, $0.95 per revenue vehicle mile, $125,300 per electrified mile and $0.05 per rider.
- The costs for BRT services are estimated as follows: $406,000 per BRT station, $68,040 per peak period bus, $23.38 per revenue vehicle hour, $4.50 per vehicle revenue mile, $132,300 per electrified BRT mile.
- The costs for commuter rail services are estimated on a flat unit-cost basis of $300.76 per revenue vehicle hour.

Conceptual operating and maintenance costs were calculated based on the alignments, operating plans and service levels previously described.

5.2 Description of Tier 2 Alternatives

The following sections provide descriptions of the Tier 2 alternatives. These descriptions cover the following areas: conceptual alignment, operating plan, capital investment requirements, conceptual capital costs, and conceptual O&M costs. Information about the how each alternative performed in the modeling of ridership, user benefits, air quality, and environmental justice impacts is included in Section 5.3 of this chapter.

5.2.1 Alternative 1A: Green Line Extension to West Medford

This alternative would provide an extension of the Green Line from Lechmere northward along the MBTA's Lowell Line terminating in the vicinity of the existing West Medford commuter rail station.

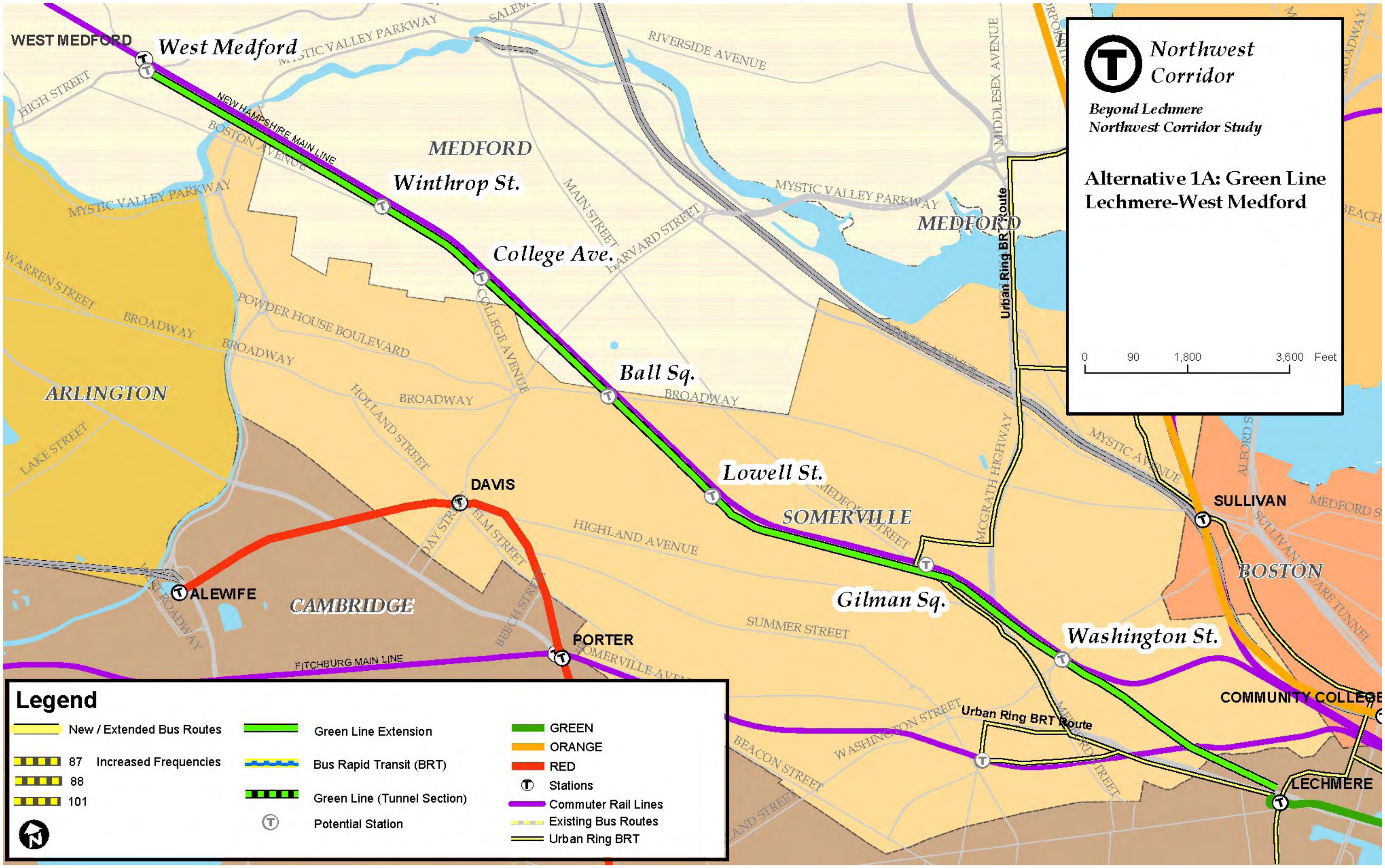
5.2.1.1 Conceptual Alignment

The alignment for this extension would start at Lechmere Station and head northwest meeting with the Lowell Line just south of Washington Street in Somerville. From Washington Street, the alignment would run parallel to the Lowell Line to West Medford.

Stations would be located in the vicinity of:

- Existing Lechmere Station (Relocated to North Side of O'Brien Hwy)
- Washington Street, Somerville (at Lowell Line)
- Medford Street, Somerville (at Lowell Line)
- Lowell Street, Somerville (at Lowell Line)
- Ball Square, Somerville (at Lowell Line)
- College Avenue, Medford (at Lowell Line)
- Winthrop Street, Medford (at Lowell Line)
- South of High Street, Medford (at Lowell Line)

Figure 5-1 shows the conceptual alignment of Alternative 1A including proposed generalized station locations. Locus maps of the proposed station areas are included in Appendix B.



Beyond Lechmere Northwest Corridor Study

Figure 5-1

Alternative 1A Conceptual Alignment

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5.2.1.2 Operating Plan

The operating plan for Alternative 1A would essentially extend the existing Green Line service at Lechmere to the northwest to West Medford. The Green Line service beyond Lechmere would operate on headways equal to that of the existing service operating between Government Center and Lechmere, which would is a two-branch service. The headways by period on the extension would be as follows:

- AM Peak – 3 minutes
- Mid Day – 4.5 minutes
- PM Peak – 3 minutes
- Evening – 5 minutes

Table 5-1 shows the conceptual travel times and station dwell time assumptions for Alternative 1A.

Table 5-1 Alternative 1A Conceptual Travel Times

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
Lechmere Station	Washington Street	1.8	0.5	2.3
Washington Street	Gillman Sq. (Medford St.)	1.2	0.5	1.7
Gillman Sq. (Medford St.)	Lowell Street Station	1.3	0.5	1.8
Lowell Street Station	Ball Square (Broadway)	0.9	0.5	1.4
Ball Square (Broadway)	College Avenue	1.2	0.5	1.7
College Avenue	Winthrop Street	0.9	0.5	1.4
Winthrop Street	West Medford (South of High St.)	1.5	0.5	2
Total Trip Time Lechmere to West Medford				**12.3**

5.2.1.3 Capital Improvements

Capital improvements for Alternative 1A include construction of light rail track and catenary along the existing railroad right-of-way between the relocated Lechmere Station and West Medford. This includes use of the "Yard 8" right-of-way between Lechmere and Washington Street and along the Lowell Line between Washington Street and West Medford. The service would end prior to the High Street grade crossing. A maintenance facility for light maintenance of the Green Line fleet would be constructed to accommodate the existing Lechmere fleet and the additional fleet of vehicles needed for the new service.

In addition to the track construction, some of the existing bridges along the right-of-way would need to be reconstructed to accommodate the additional tracks. The structures that would need to be built/rebuilt include: Red Bridge, Medford Street, School Street, Cedar Street, Broadway, Harvard Street, College Avenue, Winthrop Street, North Street, and the Mystic Valley Parkway/Mystic River.

Alternative 1A would require the acquisition of 38 Green Line vehicles to operate the service: 33 vehicles would be in active daily service and five would be spares.

Figure 5-2 shows a typical cross-section along the Alternative 1A right-of-way, with the proposed light rail transit (LRT) tracks adjacent to the existing commuter rail tracks.

Figure 5-3 shows a LRT station plan and elevation, while Figure 5-4 shows a typical LRT station section.

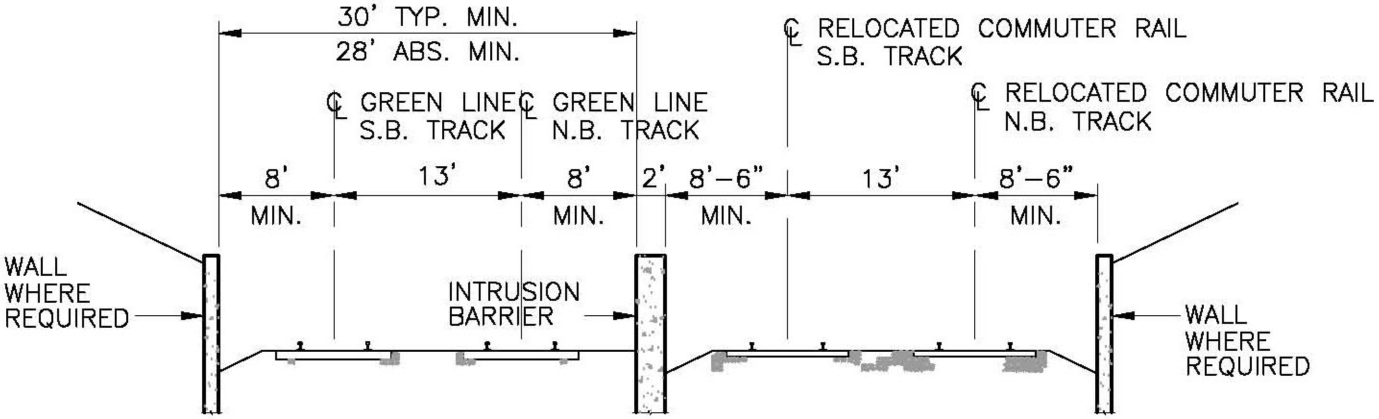

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Figure 5-2

Typical Section: Proposed LRT with Commuter Rail

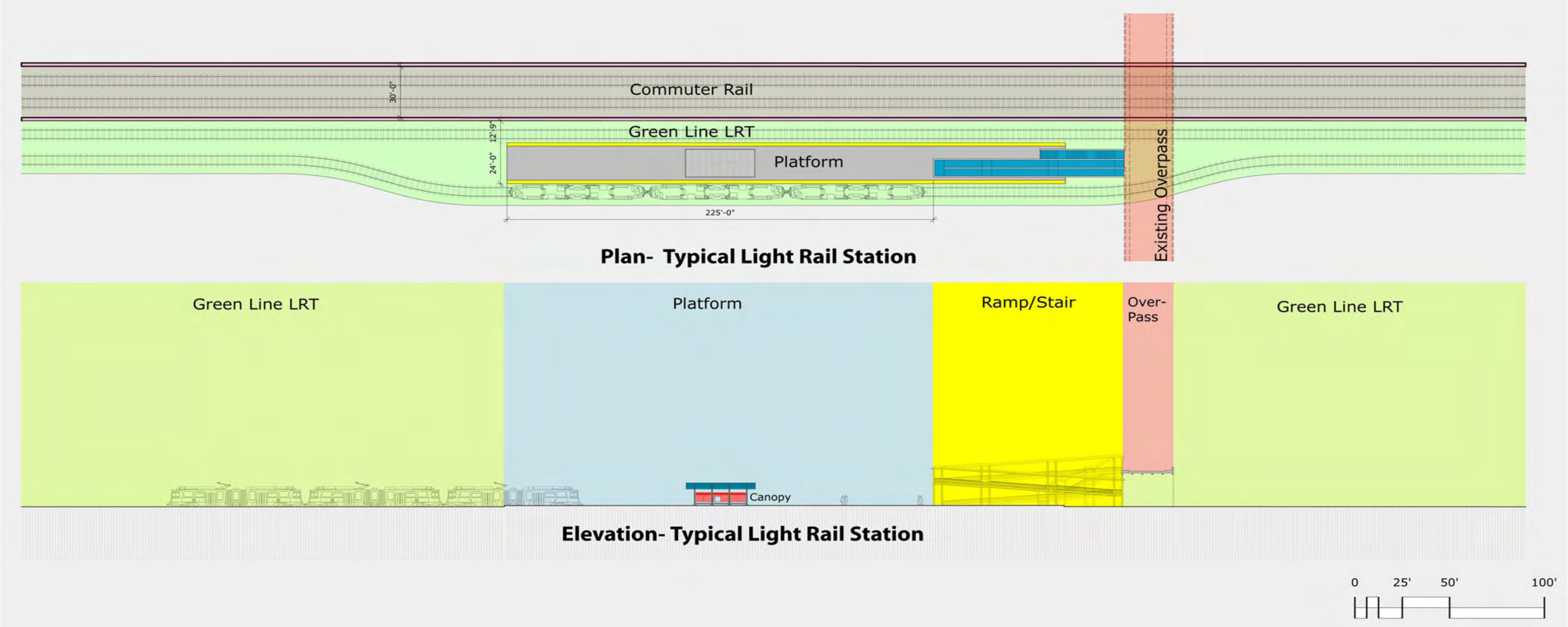

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Figure 5-3

Typical LRT Station Plan and Elevation

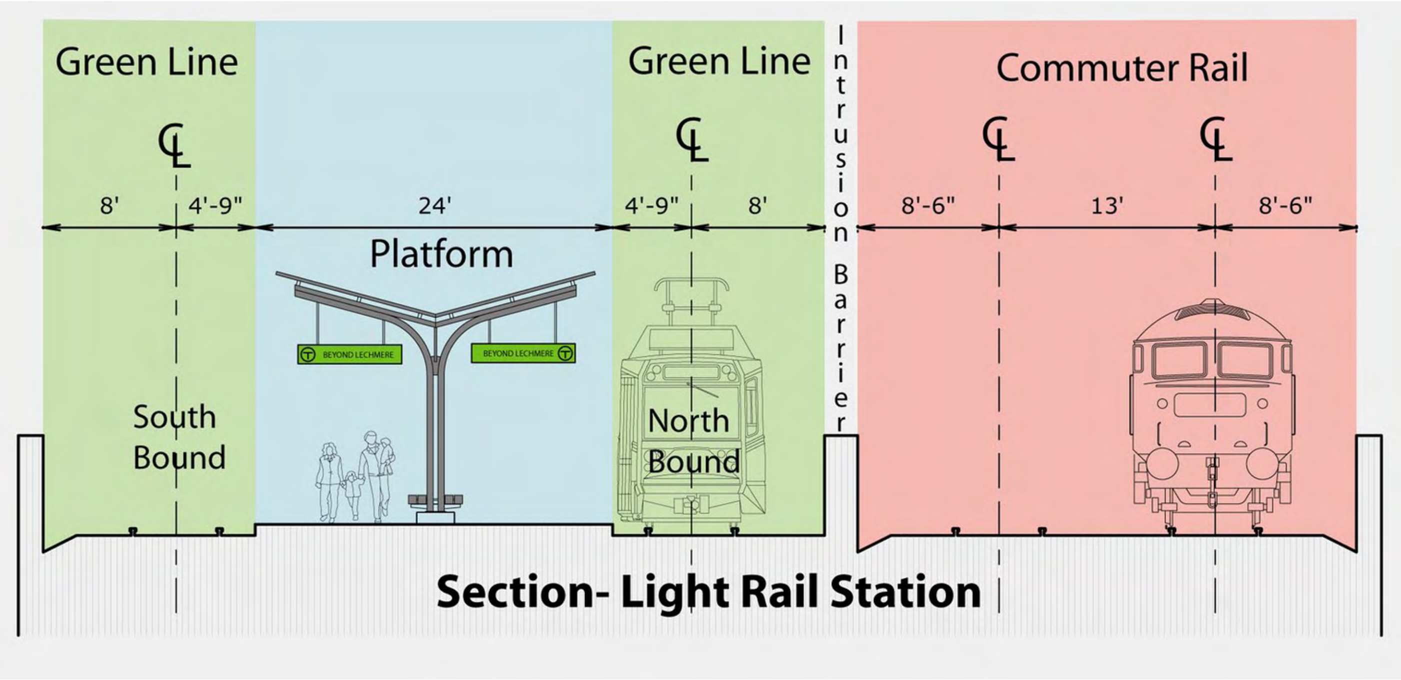

Figure 5-4

Typical LRT Station Section

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5.2.1.4 Conceptual Capital Costs

The conceptual capital cost of Alternative 1A is estimated at approximately $390 million in 2005 dollars. Of this cost, about $284 million represents infrastructure costs and $106 million represents vehicle acquisition costs. Further detail on the capital cost estimate for Alternative 1A is included in Appendix C.

5.2.1.5 Conceptual Operating & Maintenance Costs

The conceptual O&M cost of Alternative 1A is estimated to be approximately $9.9 million per year in 2005 dollars. Further detail on the O&M cost estimate for Alternative 1A is included in Appendix D.

5.2.2 Alternative 1C: Green Line Extension to West Medford and Union Square

This alternative would provide Green Line service to Union Square and to West Medford via a two-branch operation. One branch would operate from Lechmere Station to West Medford along the Lowell Line as described in Section 5.2.1 on Alternative 1A. The second branch would operate along the Fitchburg Line from Lechmere into a terminus at Union Square.

5.2.2.1 Alignment

The alignment for this extension would include two Green Line branches both extending from Lechmere, with one going to West Medford and the other going to Union Square in Somerville. The West Medford Branch would begin at Lechmere Station and head northwest meeting with the Lowell Line just south of Washington Street in Somerville. From Washington Street, the alignment would run parallel to the Lowell Line to West Medford. The Union Square Branch would start at Lechmere Station and head northwest following the Fitchburg Line to the Union Square area.

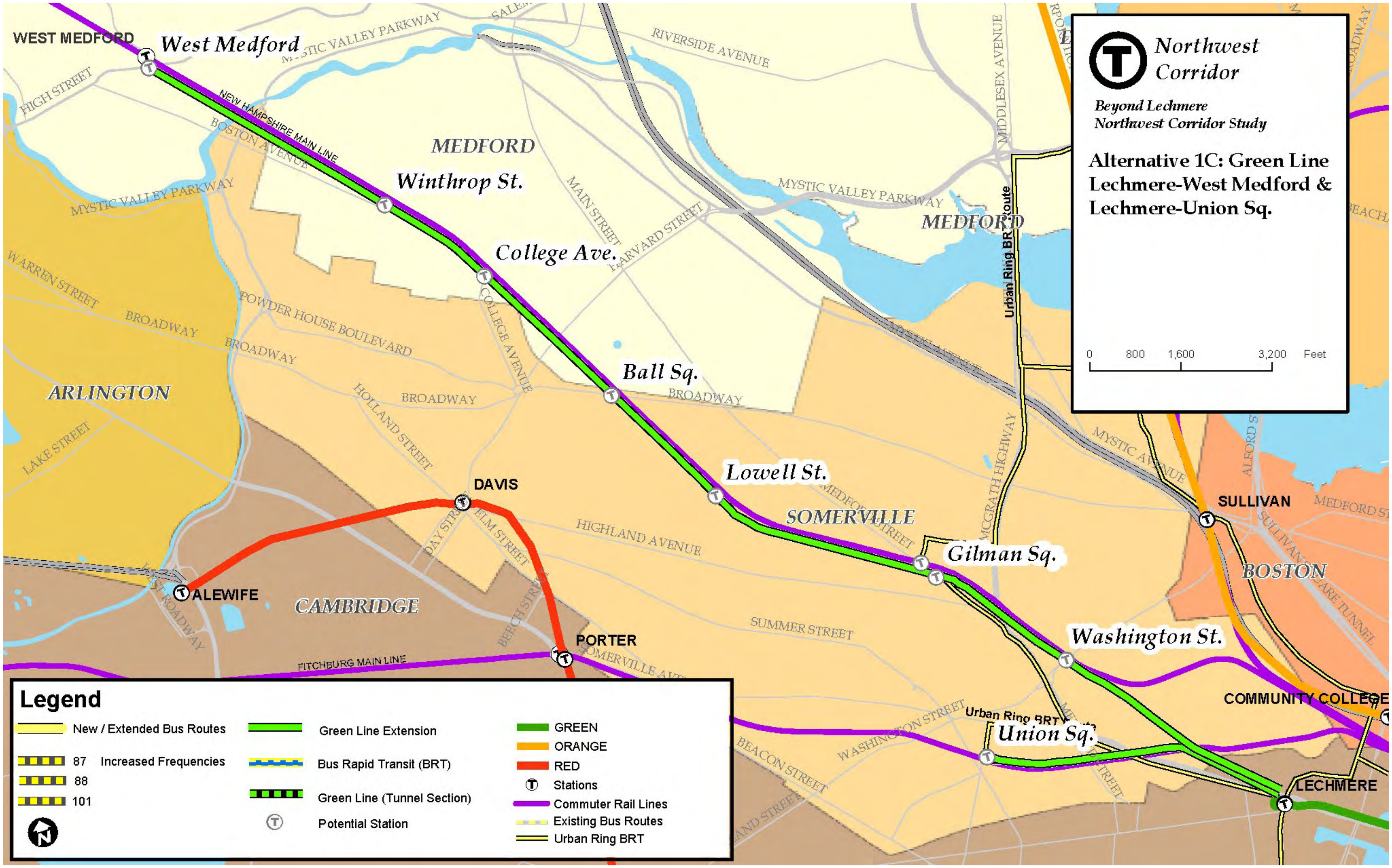
Stations for the West Medford Branch would be located in the vicinity of:

- Existing Lechmere Station (Relocated to North Side of O'Brien Hwy)
- Washington Street, Somerville (at Lowell Line)
- Medford Street, Somerville (at Lowell Line)
- Lowell Street, Somerville (at Lowell Line)
- Ball Square, Somerville (at Lowell Line)
- College Avenue, Medford (at Lowell Line)
- Winthrop Street, Medford (at Lowell Line)
- South of High Street, Medford (at Lowell Line)

Stations for the Union Square Branch would be located in the vicinity of:

- Existing Lechmere Station (Relocated to North Side of O'Brien Hwy)
- Union Square/Webster Avenue (at Fitchburg Line)

Figure 5-5 shows the conceptual alignment of Alternative 1C including proposed generalized station locations. Locus maps of the proposed station areas are included in Appendix B.



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Beyond Lechmere Northwest Corridor Study

Figure 5-5

Alternative 1C Conceptual Alignment

5.2.2.2 Operating Plan

The operating plan for Alternative 1C would essentially extend the existing Green Line service at Lechmere to the northwest to West Medford and to Union Square. The Green Line service beyond Lechmere would operate on headways equal to that of the existing service operating between Government Center and Lechmere. However, the service would be split so that one branch would operate to Union Square and one branch would operate to West Medford. The headways by period on the extension would be as follows:

West Medford Branch

- AM Peak – 5 minutes
- Mid Day – 10 minutes
- PM Peak – 5 minutes
- Evening – 10 minute

Union Square Branch

- AM Peak – 7 minutes
- Mid Day – 9 minutes
- PM Peak – 7 minutes
- Evening – 10 minute

Variations of this alternative, which have not been evaluated in this study phase, would be to extend a second Green Line branch partially or fully to West Medford. Table 5-2 shows the conceptual travel times for Alternative 1C.

Table 5-2 Alternative 1C Conceptual Travel Times

West Medford Branch

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
Lechmere Station	Washington Street	1.8	0.5	2.3
Washington Street	Gillman Sq. (Medford St.)	1.2	0.5	1.7
Gillman Sq. (Medford St.)	Lowell Street Station	1.3	0.5	1.8
Lowell Street Station	Ball Square (Broadway)	0.9	0.5	1.4
Ball Square (Broadway)	College Avenue	1.2	0.5	1.7
College Avenue	Winthrop Street	0.9	0.5	1.4
Winthrop Street	West Medford (South of High St.)	1.5	0.5	2
			Total Trip Time Lechmere to West Medford	**12.3**

Union Square Branch

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
Lechmere Station	Union Sq. (Webster Ave.)	4.5	0.0	4.5
			Total Trip Time Lechmere to West Medford	**4.5**

5.2.2.3 Capital Improvements

Capital improvements for Alternative 1C include the same as those in Alternative 1A along the alignment to West Medford. With the addition of the service to Union Square, light rail track and catenary would be constructed along the Fitchburg Line between "Red Bridge" and the proposed Union Square Station near Webster Street. The alignment and necessary improvements along this route are conceptual and have been developed in order to assess the concept of service to Union Square. Alternative routings between Lechmere and Union Square could be considered in the future, including tunneling along Somerville Avenue between McGrath Highway and Union Square, and/or several possible street running alignments. The costs for these alternative alignment options would differ from the alternative currently being considered.

The alignment to Union Square would require extensive reconfiguration of the existing commuter rail and freight rail tracks between the Commuter Rail Maintenance Facility and Webster Avenue. In addition, all of the existing bridges along the right-of-way would need to be reconstructed to accommodate the additional tracks, including: McGrath Highway, Medford Street, and Prospect Street.

Alternative 1C would require the acquisition of 32 vehicles to operate the service: 28 vehicles would be in active daily service and four would be spares. This alternative requires six fewer vehicles than would be required for Alternative 1A, due to the fact that the Green Line service in Alternative 1C is split between two branches and that the Union Square Branch is considerably shorter than the branch to West Medford. The shorter distance means that the vehicles serving the Union Square branch can be cycled more quickly, leading to a reduction in the total number of vehicles required for Alternative 1C.

The typical section of the new LRT tracks adjacent to the existing commuter rail tracks was shown previously in Figure 5-2.

The typical plan, elevation and section for the stations in this alternative are the same as those for Alternative 1A, shown in Figures 5-3 and 5-4.

5.2.2.4 Conceptual Capital Costs

The conceptual capital cost of Alternative 1C is estimated to be approximately $438 million in 2005 dollars. Of this cost, about $348 million represents infrastructure costs and approximately $90 million represents vehicle acquisition costs. The vehicle cost in this alternative is slightly lower than the cost in Alternative 1A because the number of vehicles required to operate the service is less, as explained in Section 5.2.2.3. Further detail on the capital cost estimate for Alternative 1C is included in Appendix C.

5.2.2.5 Conceptual Operating & Maintenance Costs

The conceptual O&M cost of Alternative 1C is estimated to be approximately $8.7 million per year in 2005 dollars. The O&M cost for Alternative 1C is slightly less than for Alternative 1A because the number of vehicle-hours and vehicle-miles of service being offered in this alternative is lower, due to the shorter length of the Union Square branch. Further detail on the O&M cost estimate for Alternative 1C is included in Appendix D.

5.2.3 Alternative 2B: BRT to West Medford, Green Line to Union Square

In this alternative, high-capacity BRT buses would operate on a two-lane paved roadway within the Lowell Line railroad corridor to West Medford. A Green Line segment would operate along the Fitchburg Line from Lechmere with a terminus at Union Square.

5.2.3.1 Alignment

The alignment for this extension would include one BRT alignment and one Green Line extension. The two services would both originate from Lechmere Station following the same alignments as Alternative 1C, with the BRT going to West Medford and the Green Line going to Union Square in Somerville. The BRT service alignment would begin at Lechmere Station and head northwest meeting with the Lowell Line just south of Washington Street in Somerville. From Washington Street, the alignment would run parallel to the Lowell Line to West Medford. The Union Square Branch would begin at Lechmere Station and head northwest following the Fitchburg Line to the Union Square area.

Stations for the West Medford BRT would be located in the vicinity of:

- Existing Lechmere Station (Relocated to North Side of O'Brien Hwy)
- Washington Street, Somerville (at Lowell Line)
- Medford Street, Somerville (at Lowell Line)
- Lowell Street, Somerville (at Lowell Line)
- Ball Square, Somerville (at Lowell Line)
- College Avenue, Medford (at Lowell Line)
- Winthrop Street, Medford (at Lowell Line)
- South of High Street, Medford (at Lowell Line)

Stations for the Union Square Branch would be located in the vicinity of:

- Existing Lechmere Station (Relocated to North Side of O'Brien Hwy)
- Webster Avenue (at Fitchburg Line)

Figure 5-6 shows the conceptual alignment of Alternative 2B including proposed generalized station locations. Locus maps of these proposed station areas are included in Appendix B.

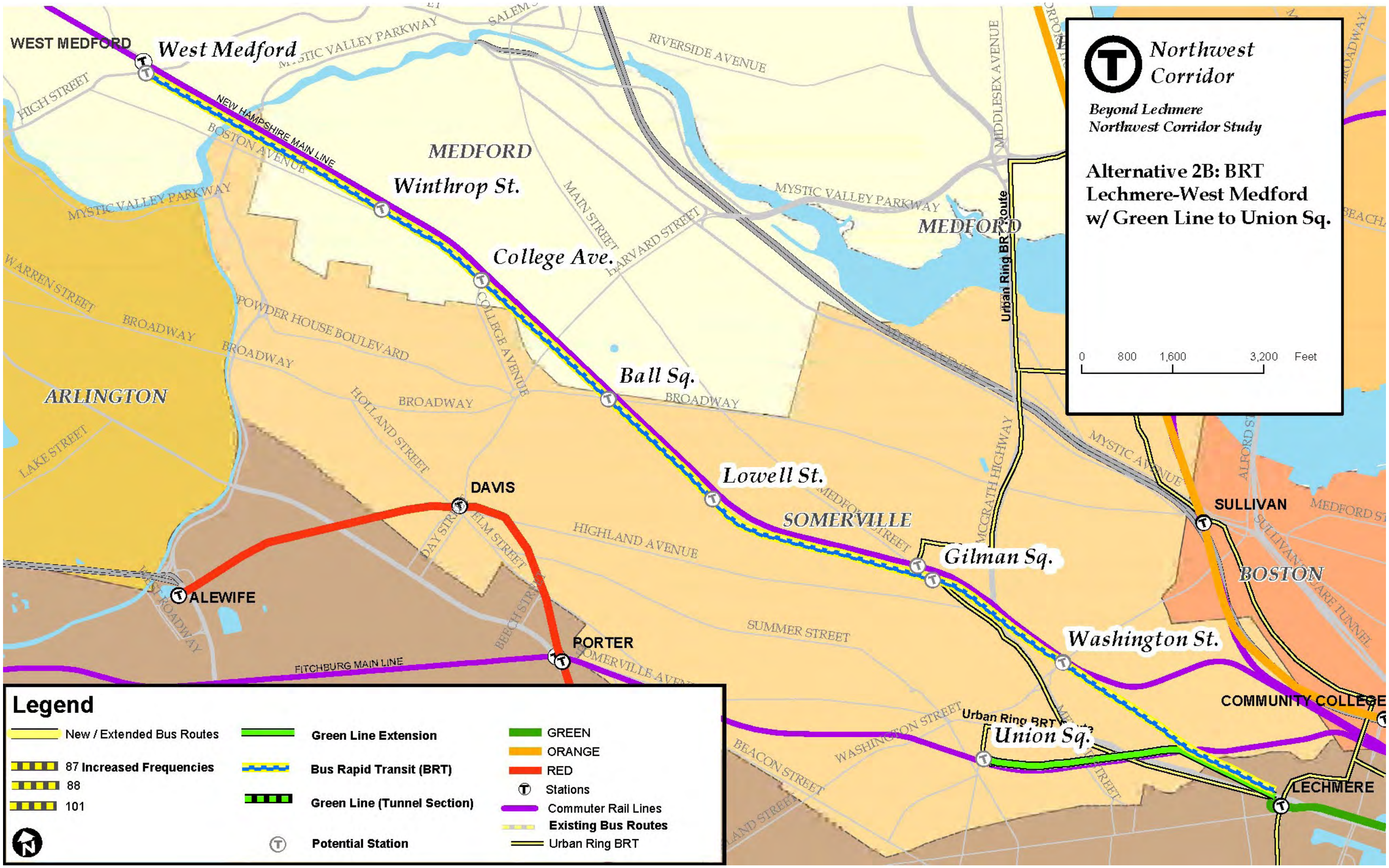

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Figure 5-6

Alternative 2B Conceptual Alignment

5.2.3.2 Operating Plan

The operating plan for Alternative 2B would extend the Green Line from Lechmere to Union Square, and establish a high-frequency BRT service along the Lowell Line to West Medford. Headways by period on the new services in Alternative 2B would be as follows:

West Medford BRT

The West Medford BRT service would operate on headways similar to that of the Green Line, if Green Line rail service were to operate along this line.

- AM Peak – 3 minutes
- Mid Day – 4.5 minutes
- PM Peak – 3 minute
- Evening – 5 minute

Union Square Green Line

The Green Line Service would operate on headways equal to that of the existing service operating between Government Center and Lechmere, which is a two-branch service.

- AM Peak – 3 minutes
- Mid Day – 4.5 minutes
- PM Peak – 3 minute
- Evening – 5 minute

Table 5-3 shows the conceptual travel times for Alternative 2B. It is worthwhile to note that the travel time between Lechmere Station and the proposed Washington Street Station is assumed to be longer in this alternative than in Alternatives 1A and 1C due to the extra time required for the BRT vehicles to circulate through Lechmere Station.

Table 5-3 Alternative 2B Conceptual Travel Times

West Medford BRT

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
Lechmere Station	Washington Street	3.9	0.5	4.4
Washington Street	Gillman Sq. (Medford St.)	1.2	0.5	1.7
Gillman Sq. (Medford St.)	Lowell Street Station	1.3	0.5	1.8
Lowell Street Station	Ball Square (Broadway)	0.9	0.5	1.4
Ball Square (Broadway)	College Avenue	1.2	0.5	1.7
College Avenue	Winthrop Street	0.9	0.5	1.4
Winthrop Street	West Medford (South of High St.)	1.5	0.5	2
Total Trip Time Lechmere to West Medford				**14.4**

Union Square Branch

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
Lechmere Station	Union Square (Webster Ave.)	4.5	0.0	4.5
		Total Trip Time Lechmere to West Medford		**4.5**

5.2.3.3 Infrastructure Requirements

Capital improvements for Alternative 2B would be similar to those in Alternative 1C, with some changes to accommodate the BRT service along the Lowell Line in lieu of Green Line service. These differences include construction of a two-lane, lighted, busway with a drainage system along the corridor. Signalization along the busway will be limited to the station areas. A maintenance facility for the bus fleet will need to be constructed for the new fleet of vehicles. All other right-of-way improvements will be the same as for light rail, including the crash wall, bridge reconstruction and commuter rail track relocation on the Lowell Line.

Figure 5-7 shows a typical cross-section along the Lowell Line right-of-way, with the proposed BRT busway adjacent to the existing commuter rail tracks.

Two platform configurations could be used at stations on the BRT segment of Alternative 2B. One configuration would have center platforms, while the other would have staggered side platforms. The center platform option would require that buses either travel opposite the usual flow of vehicle traffic, or that buses be equipped with doors on both sides to allow boarding on the center platform. The staggered side platform option would allow buses to travel in the standard direction of vehicle traffic; however, these stations would be considerably longer than the center platform stations.

Figure 5-8 shows a typical BRT station plan and elevation with center platforms. Figure 5-9 shows a typical BRT station plan and elevation with staggered side platforms. Figure 5-10 shows typical sections for both configurations. A typical LRT station plan, elevation, and section were presented previously in Figures 5-3 and 5-4.

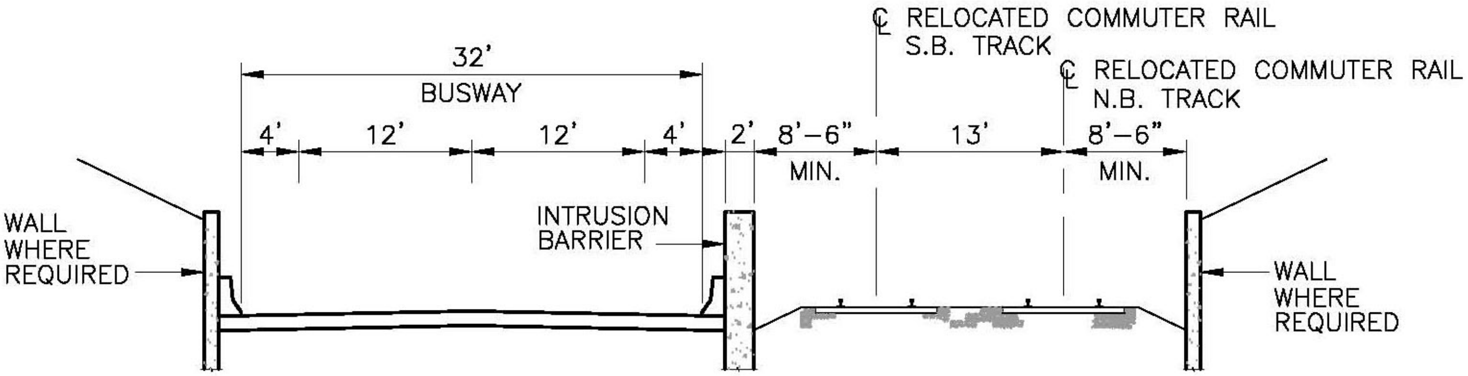

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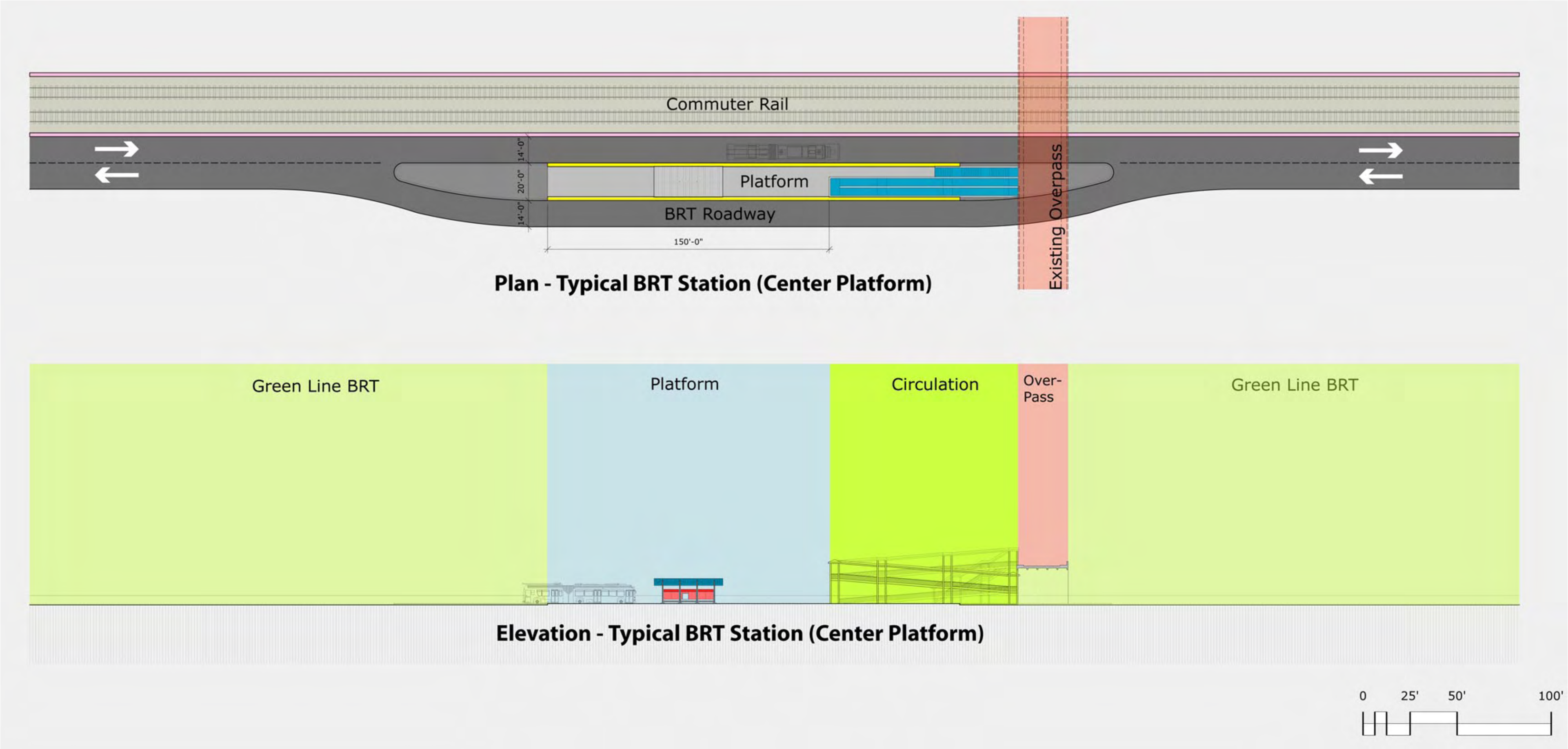
Figure 5-7

Typical Section: Proposed BRT with Commuter Rail



Plan - Typical BRT Station (Center Platform)

Elevation - Typical BRT Station (Center Platform)

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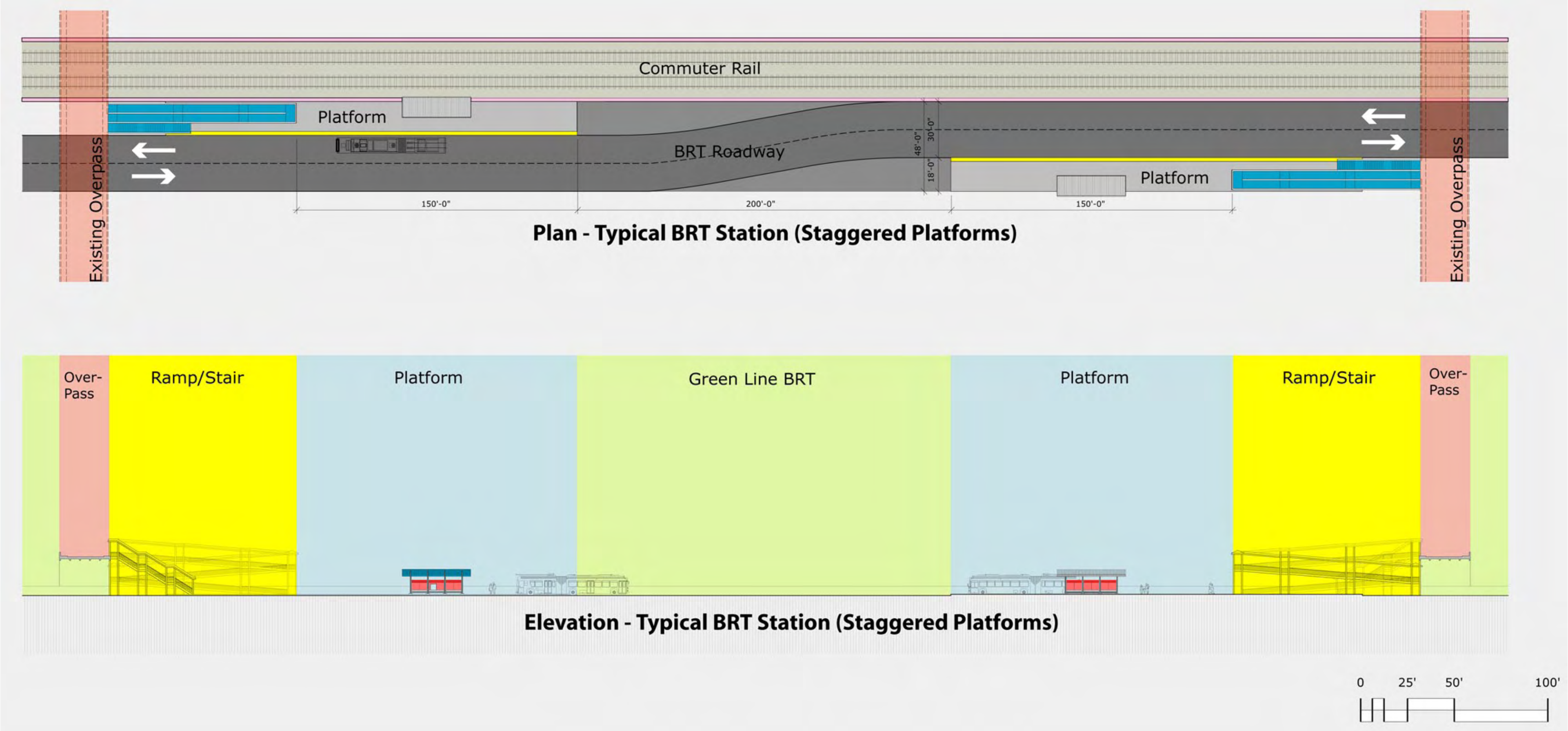
Figure 5-8

Typical BRT Station Plan and Elevation (Center Platform)



Plan - Typical BRT Station (Staggered Platforms)

Elevation - Typical BRT Station (Staggered Platforms)

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Figure 5-9

Typical BRT Station Plan and Elevation (Staggered Platform)

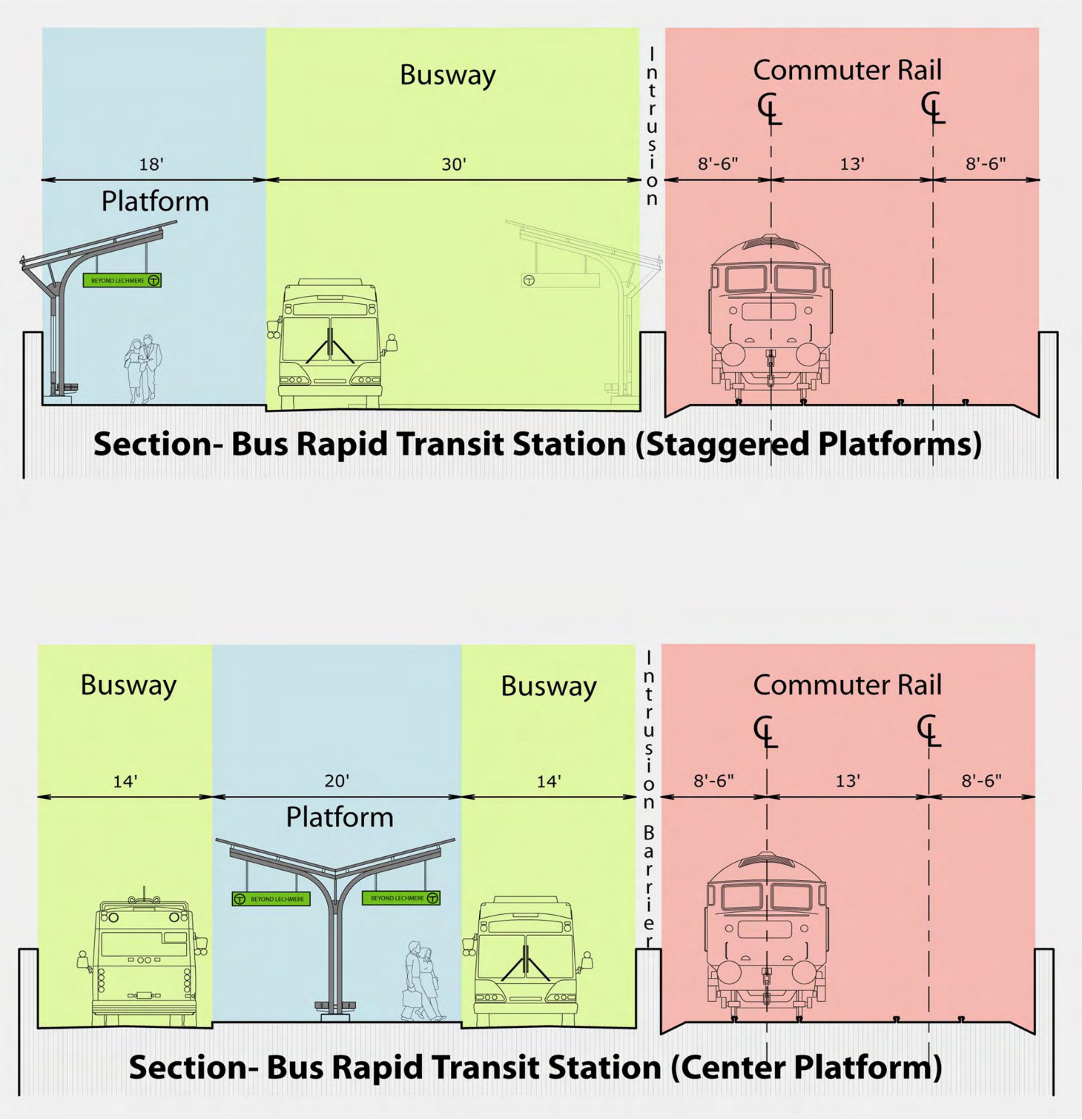

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Figure 5-10

Typical BRT Station Sections

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5.2.3.4 Conceptual Capital Costs

The conceptual capital cost of Alternative 2B is estimated to be approximately $340 million in 2005 dollars. Of this cost, about $275 million represents infrastructure costs and approximately $65 million represents vehicle acquisition costs. The infrastructure cost in this alternative is significantly lower than in Alternative 1C because system costs are significantly less on the BRT segment than on the Green Line segment, and because unit costs of BRT vehicles are significantly less than Green Line vehicles. Further detail on the capital cost estimate for Alternative 2B is included in Appendix C.

5.2.3.5 Conceptual Operating & Maintenance Costs

The conceptual O&M cost of Alternative 1C is estimated to be approximately $11.1 million per year in 2005 dollars. Further detail on the O&M cost estimate for Alternative 2B is included in Appendix D.

5.2.4 Alternatives 3A and 3B: Commuter Rail Shuttle Service

Alternatives 3A and 3B would provide more frequent commuter rail service and additional stations on the Lowell Line through Somerville to West Medford. Alternative 3A would provide this enhanced service between North Station and West Medford, while Alternative 3B would continue this enhanced service to the Anderson RTC in Woburn. The alternative of continuing the shuttle service to Woburn was introduced based on stakeholder input for several reasons: 1) the Anderson RTC is a good intercept point for drivers from the north and could contribute to the goal of diverting auto trips to transit; 2) the original concept for the Anderson RTC considered the potential for a shuttle service of this type, and the facility was designed to accommodate it; and 3) the Anderson RTC has a substantial park-and-ride capacity and the potential for expansion if necessary.

5.2.4.1 Alignment

The alignment for this service would operate entirely along the existing Lowell Line with the addition of several stations. Alternative 3A would operate between North Station and West Medford, while Alternative 3B would operate between North Station and the Anderson Regional Transportation Center in Woburn. In both Alternative 3A and 3B, three new stations would be added between North Station and West Medford. The number of stations added in these alternatives is less than in Alternatives 1A, 1C, or 2B due to the operational characteristics of commuter rail trains and the desired station spacing for commuter rail services.

Stations for Alternative 3A would be located in the vicinity of:

- Existing North Station
- Medford Street, Somerville (at Lowell Line)
- Lowell Street, Somerville (at Lowell Line)
- Winthrop Street, Medford (at Lowell Line)
- South of High Street, Medford (at Lowell Line)

Stations for Alternative 3B would include the above generalized locations plus the following additional locations:

- Existing Wedgemere Station
- Existing Winchester Center Station
- Existing Mishawum Station
- Existing Anderson RTC Station

Figure 5-11 shows the conceptual alignment of the commuter rail shuttle service alternatives including proposed generalized station locations within the Beyond Lechmere study area. Station locations outside the study area in Alternative 3B are not shown in this figure but would include the four locations listed above.

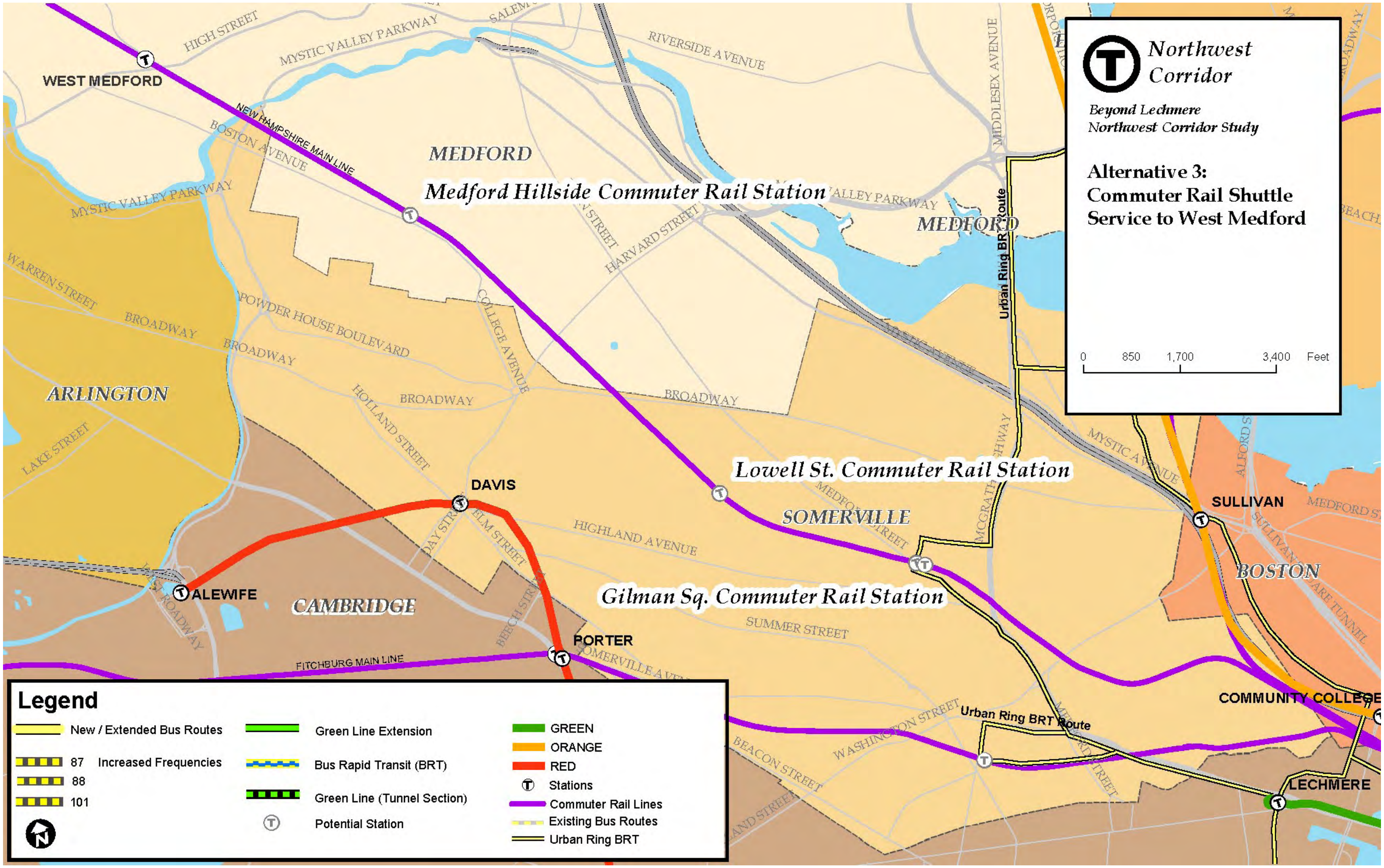

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Figure 5-11

Alternative 3 Conceptual Alignment

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5.2.4.2 Operating Plan

The operating plan for Alternatives 3A and 3B would be similar. The commuter rail shuttle service would operate along the same alignment but on more frequent headways than the existing Lowell Line service. There would be no change to the headways on the existing Lowell Line service. Average anticipated headways on the shuttle service are as follows:

- AM Peak – 15 minutes
- Mid Day – 45 minutes
- PM Peak – 15 minutes
- Evening – 45 minutes

As noted in Section 5.1.2.2, these peak headways are the shortest possible given the time required to turn a train around at North Station.

Table 5-4 shows the estimated travel times on Alternative 3A to West Medford.

Table 5-4 Alternative 3A Conceptual Travel Times

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
North Station	Gillman Sq. (Medford St.)	9	0.75	9.75
Gillman Sq. (Medford St.)	Lowell Street Station	1.9	0.75	2.65
Lowell Street Station	Winthrop Street	2.4	0.75	3.15
Winthrop Street	West Medford (South of High St.)	2.5	0.75	3.25
			Total Trip Time North Station to West Medford	**18.8**

Table 5-5 shows the estimated travel times on the Anderson RTC commuter rail shuttle in Alternative 3B.

Table 5-5 Alternative 3B Conceptual Travel Times: Anderson RTC Commuter Rail Shuttle

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
North Station	Gilman Sq. (Medford St.)	9	0.75	9.75
Gilman Sq. (Medford St.)	Lowell Street Station	1.9	0.75	2.65
Lowell Street Station	Winthrop Street	2.4	0.75	3.15
Winthrop Street	West Medford (South of High St.)	2.5	0.75	3.25
			Trip Time North Station to West Medford	**18.8**
Travel and Trip times between existing stations (Wedgemere, Winchester, Mishawum and Anderson) would remain as existing.				

Travel times for the Lowell Line service would remain as is currently scheduled for the service between Lowell and Anderson RTC. All station stops between Anderson RTC and North Station would be eliminated for this service. This would yield a travel time savings of approximately 5 minutes on the Lowell Line from the Anderson RTC and points north. Table 5-6 summarizes the estimated travel times on this proposed Lowell Line express service.

Table 5-6 Alternative 3B Conceptual Travel Times: Lowell Line Commuter Rail Service (Express)

From Station	To Station	Travel Time between Stations (minutes)	Station Dwell Time	Travel Time (including Dwell)
North Station	Anderson RTC	21	N/A	21
Travel and Trip times between remaining existing stations (Wilmington, N. Billerica, and Lowell) would remain as existing.				

5.2.4.3 Capital Improvements

Capital improvements for Alternative 3A include construction of a third commuter rail track along the New Hampshire Main Line for some of the distance between North Station and West Medford. The construction of the third track will extend from Lowell Street to North Street. In addition to the third commuter rail track, the interlockings will be reconstructed in both the Washington Street and Lowell Street areas to operate around the additional traffic proposed for the line. The existing commuter rail signal system would be modified to accommodate the additional track.

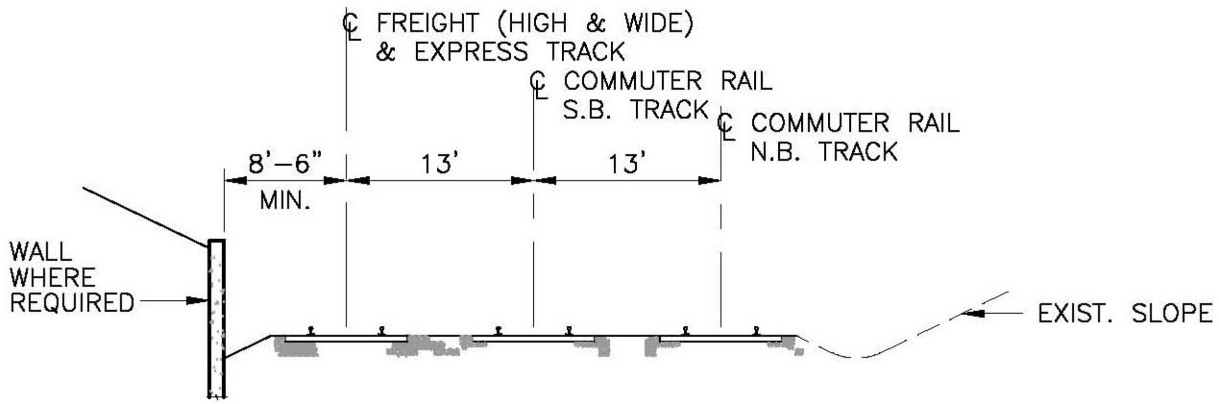
Although much of the same right-of-way work would be necessary to accommodate the third commuter rail track (i.e. cuts, retaining walls, etc.) as envisioned for Alternative 1A, reconstruction of bridges would be limited to the following: Cedar Street, Broadway, Harvard Street, College Avenue, Winthrop Street, and North Street.

Capital improvements for Alternative 3B include the extension of the third commuter rail track along the Lowell Line included in Alternative 3A. The third track would be extended from Lowell Street to just south of the Wedgmere Station. The addition of this third track through the West Medford area would require the reconstruction of the High Street grade crossing and the West Medford Station. A third track would also be constructed between a location north of Winchester Station (Milepost 8.28) and the existing third track in the Anderson Transportation Center area.

Construction of this segment of third track would require the reconstruction of many of the bridges along the route, modification of the signal system, and changes to the causeway located just north of Montvale Avenue, Woburn. The bridges that would require reconstruction include: Swanton Street, Aberjona River, Cross Street, Montvale Avenue, and Salem Street. The third track would also require a modification to the length and location of the Mishawum Station platforms.

Figure 5-12 shows a typical cross-section along the Lowell Line right-of-way, with the proposed triple track to accommodate the new shuttle service.

Figure 5-13 shows a typical commuter rail station plan and elevation, while Figure 5-14 shows a typical commuter rail station section.

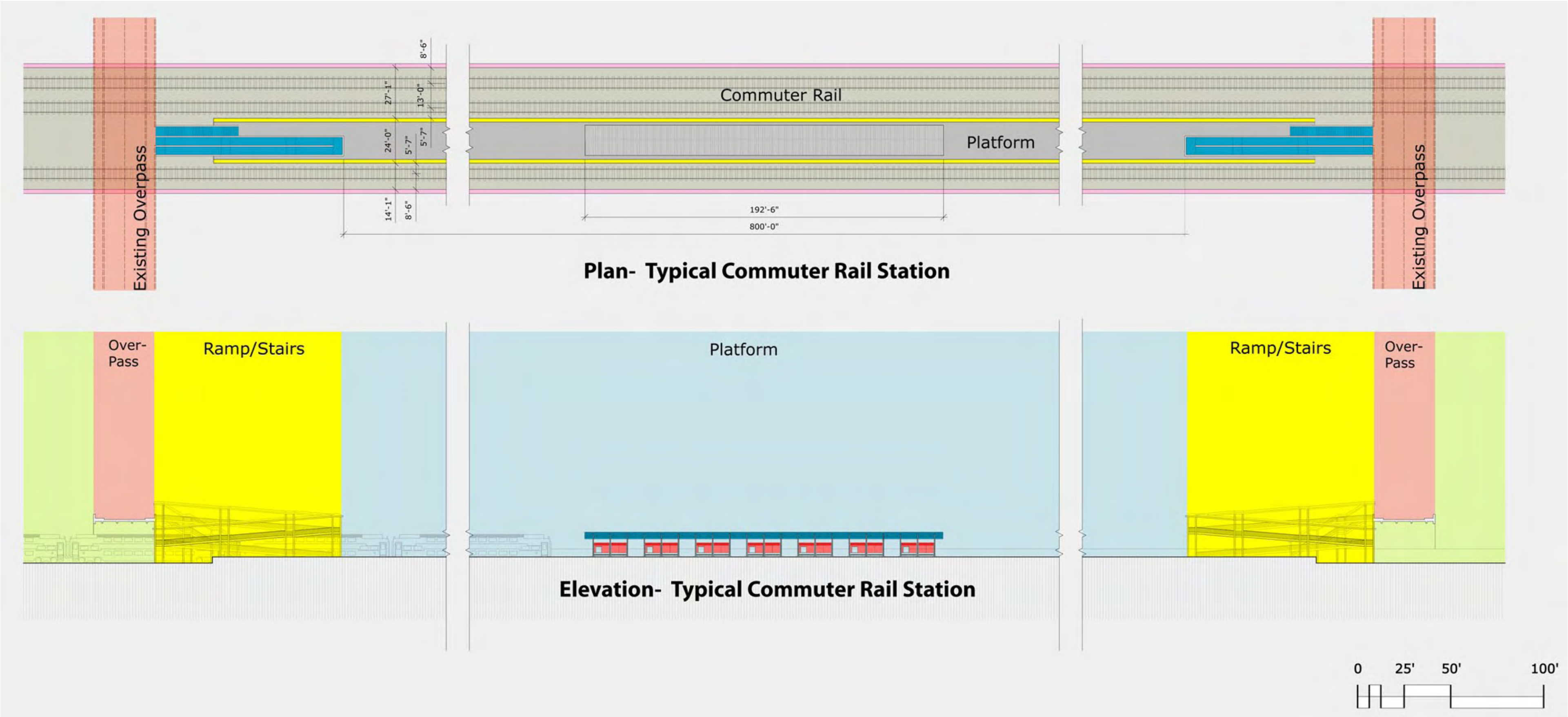

℄ FREIGHT (HIGH & WIDE) & EXPRESS TRACK
℄ COMMUTER RAIL S.B. TRACK
℄ COMMUTER RAIL N.B. TRACK
8'-6" MIN.
13'
13'
WALL WHERE REQUIRED
EXIST. SLOPE

Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

Figure 5-12

Typical Section: Commuter Rail with Proposed Third Track



Plan- Typical Commuter Rail Station

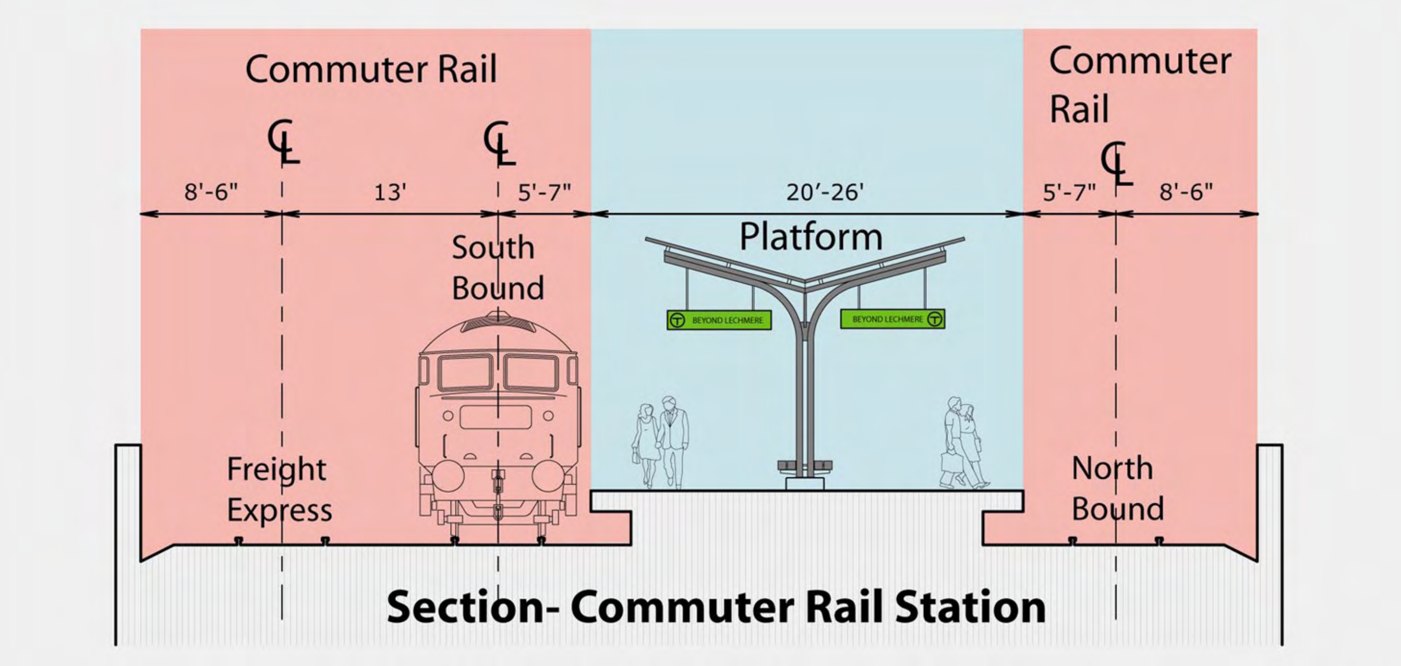
Elevation- Typical Commuter Rail Station

Beyond Lechmere Northwest Corridor Study

Massachusetts Bay Transportation Authority

Figure 5-13

Typical Commuter Rail Station Plan and Elevation



Beyond Lechmere Northwest Corridor Study

Figure 5-14

Typical Commuter Rail Station Section

**Massachusetts
Bay
Transportation
Authority**

5.2.4.4 Conceptual Capital Costs

The conceptual capital cost of Alternative 3A is estimated to be approximately $171 million in 2005 dollars. Of this cost, about $82 million represents infrastructure costs and approximately $89 million represents rail equipment acquisition costs.

The conceptual capital cost of Alternative 3B is estimated to be approximately $347 million in 2005 dollars. Of this cost, about $224 million represents infrastructure costs and approximately $123 million represents rail equipment acquisition costs.

Further detail on the capital cost estimates for Alternatives 3A and 3B is included in Appendix C.

5.2.4.5 Conceptual Operating & Maintenance Costs

The conceptual O&M cost of Alternative 3A is estimated to be approximately $3.7 million per year in 2005 dollars.

The conceptual O&M cost of Alternative 3B is estimated to be approximately $5.4 million per year in 2005 dollars.

Further detail on the O&M cost estimates for Alternatives 3A and 3B is included in Appendix D.

5.2.5 Alternative 4: Transportation System Management

The Transportation System Management (TSM) alternative is intended to address, at least in part, the project Purpose and Need with relatively low-cost changes to the existing transportation system. This alternative includes increasing headways on existing bus routes and the addition of one bus route in Somerville (Medford Hillside Circulator). Like the Build alternatives, this TSM alternative was developed at a conceptual level, and would be further developed should this project advance through the Federal environmental review process.

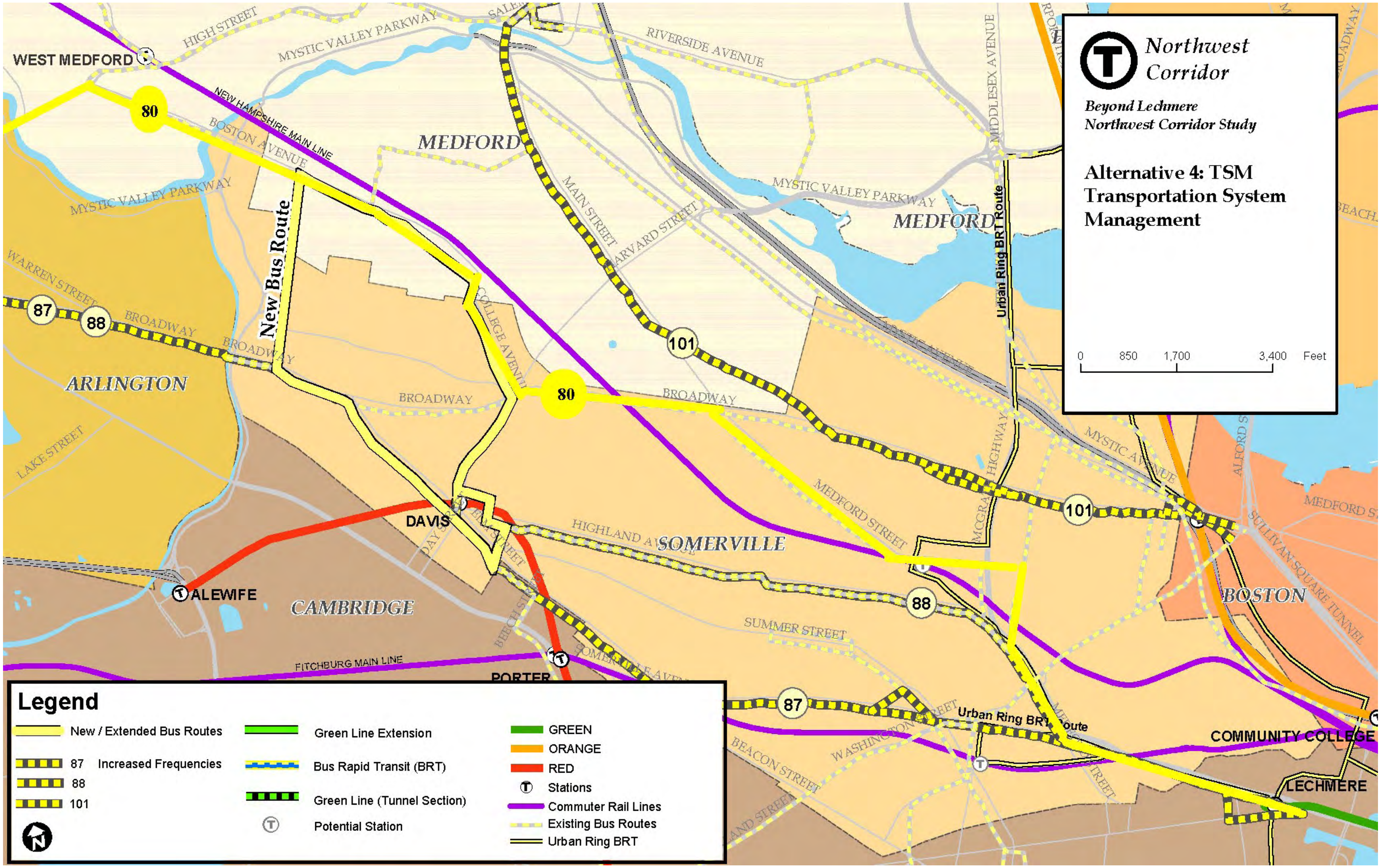
5.2.5.1 Alignment

The following is a description of the conceptual alignment of the proposed Medford Hillside Circulator route that would be included in Alternative 4:

- Originate at Davis Square
- Right on Holland Street
- Left on Broadway
- Right on North Street
- Right on Boston Avenue
- Right on College Avenue
- Left on Elm Street
- Left on Grove Street
- Left on Davis Square Busway

In this alternative, four existing bus routes – Routes 80, 87, 88, and 101 – would see increased service frequencies, but their routing would remain the same as today.

Figure 5-15 shows the conceptual alignment of Alternative 4 including both the proposed Medford Hillside Circulator and the existing bus routes that would be enhanced.



Beyond Lechmere Northwest Corridor Study

Figure 5-15

Alternative 4 Conceptual Alignment

Massachusetts Bay Transportation Authority

5.2.5.2 Operating Plan

The operating plan for Alternative 4 would increase headways on four existing bus routes and introduce one new route, the Medford Hillside Circulator.

Medford Hillside Circulator – The total trip time on the Medford Hillside Circulator would be approximately 15 minutes and the headways would be as follows:

- AM Peak – 20 minutes
- Mid Day – 20 minutes
- PM Peak – 20 minutes
- Evening – 60 minutes

The proposed enhanced headways on the existing routes are summarized below.

Route 80 (route that most closely parallels the primary Green Line alignment) – Headways for this route would be increased to:

- AM Peak – 10 minutes
- Mid Day – 20 minutes
- PM Peak – 10 minutes
- Evening – 20 minutes

Route 88 – Headways for this route would be increased to:

- AM Peak – 10 minutes
- Mid Day – 20 minutes
- PM Peak – 10 minutes
- Evening – 20 minutes

Route 87 – Headways for this route would be increased to:

- AM Peak – 10 minutes
- Mid Day – 20 minutes
- PM Peak – 10 minutes
- Evening – 20 minutes

Route 101 – Headways for this route would be increased to:

- AM Peak – 10 minutes
- Mid Day – 20 minutes
- PM Peak – 10 minutes
- Evening – 20 minutes

5.2.5.3 Capital Improvements

Alternative 4 would involve no changes to fixed infrastructure. However, it would require the purchase of 12 standard 40-foot transit buses. It is expected that these buses would be Emissions Control Diesel buses, consistent with the MBTA’s plans for future bus procurements.

5.2.5.4 Conceptual Capital Costs

The conceptual capital cost of Alternative 4 is estimated to be approximately $4.6 million in 2005 dollars. This cost is entirely for vehicle acquisition.

5.2.5.5 Conceptual Operating & Maintenance Costs

The conceptual O&M cost of Alternative 4 is estimated to be approximately $1.8 million per year in 2005 dollars.

Further detail on the O&M cost estimate for Alternative 4 is included in Appendix D.

5.3 CTPS Travel Demand Modeling

An important part of the evaluation of the Tier 2 alternatives was modeling of benefits and impacts conducted by the Central Transportation Planning Staff (CTPS). CTPS maintains the state's travel demand model that is used to estimate the benefits and impacts of proposed transportation projects in eastern Massachusetts. For the Beyond Lechmere Northwest Corridor Study, the MBTA had CTPS run the model and provide forecasts in support of the evaluation of the Tier 2 alternatives.

The modeling effort for the Tier 2 alternatives encompassed the following main areas:

- Ridership
- Revenue
- Highway and vehicular travel
- Air quality
- Environmental justice
- User benefit

5.3.1 Methodology and Assumptions

The travel demand model that was used for the Beyond Lechmere Northwest Corridor Study is based on procedures that have evolved over many years at CTPS. The model set is based on the traditional four-step urban transportation planning process of trip generation, trip distribution, mode choice, and trip assignment and is implemented in the EMME/2 software package. This process is employed to estimate daily transit ridership and highway traffic volumes, primarily on the basis of forecasts of study area demography, land use assumptions, and projected highway and transit improvements. The model set simulates travel on the entire eastern Massachusetts transit and highway system. A full description of the methodology used in the travel demand modeling for the Beyond Lechmere Northwest Corridor Study is included in Appendix E.

A number of assumptions in many areas are made when the travel demand model is run for a project of this type. These assumptions are summarized fully in Appendix E. However, it is important to note several key assumptions here:

- Seven scenarios were included in the modeling effort: the five Build alternatives (Alternatives 1A, 1C, 2B, 3A and 3B), the Transportation System Management (TSM) Alternative, and the No-Build Alternative. The service parameters such as headways and travel times described in Section 5.2 of this chapter were used as assumptions in the travel demand model.
- The modeled area encompasses 164 cities and towns in eastern Massachusetts and includes 986 internal Traffic Analysis Zones (TAZs).

- The base year for this study was 2004 and the horizon year for forecasts was 2025.
- The transit network in the model represents all MBTA bus and rail services in eastern Massachusetts, as well as private express buses and Boston Harbor ferries. For the purpose of this study, the No-Build Alternative in the model assumed that the MBTA's Urban Ring Phase II project is in place.

5.3.2 Model Results

The CTPS travel demand model produces output at a highly detailed level in many different areas, including forecast ridershship, highway and vehicular travel, air quality, and environmental justice. Outputs are produced for different times of day (e.g., AM peak, midday, PM peak, or evening) and are often produced for a number of different trip purposes (e.g., home-based work, home-based non-work, non-home-based trips). For the purpose of presenting the model results in this phase of the Beyond Lechmere Northwest Corridor Study, summary-level data (for an entire day and for all trip purposes) have been used rather than this more detailed data. However, the more detailed model results are presented in Appendix F for reference.

In the CTPS model output, data are generally produced showing the value of each indicator (e.g., linked trips on the transit system or Vehicle-Miles-Traveled on the roadway network) for each alternative including the five Build alternatives, the TSM Alternative, and the No-Build Alternative. When evaluating a proposed transportation improvement project such as that being considered in this study, however, it is most meaningful to look at the difference between the value for a given alternative as compared to the No-Build Alternative. By considering model results in this way, it is possible to see the incremental improvement generated by an alternative compared to a situation where no project is implemented. For the purpose of presenting the model results in this section, the difference between each alternative and the No-Build Alternative is presented. However, the actual values for all the alternatives including the No-Build are presented in the detailed tables in Appendix F.

The following sections briefly summarize key model results that have been used to compare the Tier 2 alternatives. Brief descriptions of each indicator are provided below, followed by a summary table (Table 5-7) showing key CTPS model results.

5.3.2.1 Ridership and Revenue

The CTPS travel demand produces several key indicators related to transit ridership. These include:

- **System-Wide Linked Trips**: A linked trip represents a single transit rider traveling from the initial Origin to ultimate Destination of their trip. A linked trip may consist of several unlinked trips (defined below). The change in system-wide linked trips in a given alternative from the No-Build is an approximation of how many new transit riders are generated by the alternative. For the Tier 2 alternatives, the incremental system-wide linked trips in 2025 range from 14,160 daily trips for Alternative 1A to 1,580 daily trips for the TSM Alternative.
- **System-Wide Unlinked Trips**: An unlinked trip represents a single segment of travel on the transit system, such as a single trip on the Green Line or a single feeder bus trip. Several unlinked trips may be chained together to form a single linked trip. The change in system-wide unlinked trips in a given alternative from the No-Build is an approximation of how many new transit boardings are generated by the alternative on the entire transit system. For the Tier 2 alternatives, the incremental system-wide unlinked trips in 2025 range from 31,300 daily trips for Alternative 2B to 1,600 daily trips for Alternative 1C. The large number of unlinked trips generated by Alternative 2B reflects the fact that riders must transfer between the new BRT service and the existing Green Line at Lechmere.
- **System-Wide Transfer Rate**: The transfer rate is the ratio of unlinked trips to linked trips across the transit system. In the No-Build Alternative in 2025, the system-wide transfer rate is approximately 1.38, which indicates that there are about 138 unlinked trips for every 100 linked trips made. For a transit project of this type, the most meaningful use of the system-wide transfer rate is to indicate whether a given alternative adds or avoids transfers to the system as a whole. The change in system-wide transfer rate is shown in Table 5-7. However, the most important conclusion to draw from these figures is that in 2025 Alternatives 1A and 1C help avoid transfers and Alternative 2B creates additional transfers, while Alternatives 3A, 3B, and 4 have no measurable effect on system-wide transfers.
- **Adult Cash Fare**: The incremental adult cash fare is an estimate of the amount of revenue generated by a given alternative, in comparison to the No-Build Alternative. This figure is reported on a daily basis in Table 5-7. Daily incremental adult cash fares in 2025 range from $23,706 for Alternative 1A to $927 for the TSM Alternative.

5.3.2.2 Highway and Vehicular Travel

The CTPS travel demand produces several key indicators related to highway and vehicular travel. These include:

- **Vehicle-Miles of Travel**: Vehicle-Miles of Travel, or VMT, is an estimate of the total amount of travel in private automobiles and trucks on the regional highway system. Transit projects usually generate a reduction in VMT due to the shift of travelers from the private automobile to the transit system; these VMT reductions lead to environmental benefits including reduced emissions and energy consumption. For the Tier 2 alternatives, the change in daily VMT in 2025 ranges from a reduction of 64,500 in Alternative 1A to a reduction of 6,200 in the TSM Alternative.
- **Auto Person-Trips Shifted to Transit**: Auto person-trips shifted to transit, as the name indicates, is a measure of the number of person-trips on the regional transportation system that are shifted from private automobile to transit in a given alternative. For the Tier 2 alternatives, the number of auto person-trips shifted to transit in 2025 ranges from 13,320 in Alternative 1A to 1,390 in the TSM Alternative.

5.3.2.3 Air Quality

The CTPS travel demand model characterizes the air quality benefits associated with a given alternative by estimating the reductions in region-wide emissions of several key pollutants due to the diversion of automobile trips to the transit system. The three pollutants estimated in the CTPS model are:

- Volatile Organic Compounds (VOCs)
- Nitrous Oxide (NOx)
- Carbon Monoxide (CO)

The changes in each of these emissions levels are estimated in kilograms of pollutant per day across the region, based on the emissions factors developed by the Environmental Protection Agency (EPA). For comparison, the model estimates that Alternative 1A results in a reduction of 8 kilograms of VOCs, 18 kilograms of NOx, and 555 kilograms of CO per day in 2025, while the TSM Alternative results in a reduction of 4 kilograms of VOCs, no measurable change in NOx, and a reduction of 28 kilograms of CO per day in 2025.

For rough comparison purposes, it can also be useful to estimate the quantities of key pollutants generated by the new transit service in each alternative. These pollutants are estimated based on the quantities of VMT and standard EPA emissions factors, similar to the estimates of emissions avoided due to auto trips diverted to transit. The estimates are included in Table 5-7 as a point of reference. Estimates are not produced for Alternatives 1A and 1C, and the estimate for Alternative 2B only includes emissions from the BRT vehicles. This is due to the fact that Green Line emissions are produced at the power plant (i.e., point source) rather than at the vehicle/tailpipe (i.e., mobile source) and may vary widely depending on the utility fuel mix.

5.3.2.4 Environmental Justice

The Environmental Justice (EJ) impacts of the Tier 2 alternatives were estimated in the CTPS model using three measures of accessibility. These measures of accessibility are consistent with Environmental Justice guidelines developed by the Boston Metropolitan Planning Organization (MPO):

- Employment Opportunities within 40 minutes of an Environmental Justice TAZ by transit
- Hospital Beds within 60 minutes of an Environmental Justice TAZ by transit
- Educational Opportunities (Two-Year Colleges) within 60minutes of an Environmental Justice TAZ by transit

In the CTPS model, the number of opportunities within each of these travel times was estimated for the No-Build Alternative, the five Build Alternatives and the TSM Alternative. To allow for a comparison of Tier 2 alternatives, the percent change in opportunities from the No-Build was calculated for each alternative. The model results show increases in accessibility of employment opportunities for each of the alternatives. These ranged from a 8.4% increase in accessibility to employment from Somerville EJ TAZs in Alternative 1A to a roughly 1% increase in accessibility to employment from Somerville EJ TAZs in the TSM Alternative in 2025. The CTPS model shows no changes in accessibility to hospital beds and to two-year educational opportunities for any of the Tier 2 alternatives.

5.3.2.5 User Benefit

One of the key indicators of the effectiveness of a transportation investment that can be estimated by the CTPS travel demand model is user benefit. User benefit is a measure of the aggregate number of hours of travel time saved by all users of the transportation system due to a transportation improvement project. User benefit is generally estimated as the incremental change between a Build alternative and the TSM Alternative. In the Tier 2 alternatives, the user benefit figures in 2025 range from 12,400 daily hours of user benefit in Alternative 1A to 170 daily hours of user benefit in Alternative 3A.

Table 5-7 Summary of CTPS Regional Travel Model Results

Indicator	**Alt. 1A** Green Line to West Medford	**Alt. 1C** Green Line to West Medford and Union Square	**Alt. 2B** BRT to West Medford and Green Line to Union Square	**Alt. 3A** Commuter Rail Shuttle to West Medford	**Alt. 3B** Commuter Rail Shuttle to Anderson RTC	**Alt. 4** Transportation System Management
Ridership and Revenue						
System-Wide Linked Trips	14, 160	10,060	10,590	1,670	1,890	1,580
System-Wide Unlinked Trips	9,110	1,600	31,300	2,240	2,560	2,080
System-Wide Transfer Rate	-0.01	-0.01	0.01	0.00	0.00	0.00
Adult Cash Fare	$23,700	$16,600	$19,500	$2,900	$6,000	$900
Highway/Auto Travel						
Vehicle-Miles of Travel	-64,500	-52,800	-50,900	-8,700	-10,000	-6,200
Auto Person-Trips Shifted to Transit	13,320	9,660	9,760	1,610	1,830	1,390
Air Quality – Emissions Associated with Highway/Auto Travel						
Volatile Organic Compounds (kg)	-8	-5	-4	-3	-4	-4
Nitrous Oxide (kg)	-18	-14	-2	-3	-3	0
Carbon Monoxide (kg)	-555	-393	-364	-20	-32	-28
Air Quality – Emissions Associated with Added Transit Service						
Volatile Organic Compounds (kg)	Emissions at power plant rather than at vehicle/tailpipe; emissions may vary widely depending on utility fuel mix		0	0	0	0
Nitrous Oxide (kg)			77	19	44	39
Carbon Monoxide (kg)			6	5	9	3
Environmental Justice						
Employment Opportunities within 40 minutes by transit						
EJ TAZs in Medford	+6.53%	+5.01%	+3.89%	+1.96%	+2.77%	+1.56%
EJ TAZs in Cambridge	0.00%	0.00%	0.00%	0.00%	0.00%	+2.78%
EJ TAZs in Somerville	+8.43%	+6.24%	+5.65%	+3.07%	+3.50%	+0.94%
User Benefit						
Hours of User Benefit (relative to TSM Alternative)	12,400	8,640	8,070	170	230	205,800 (relative to No-Build)

Notes:

(1) All figures are for the study horizon year, 2025.

(2) All figures are daily, relative to the No-Build Alternative (except for User Benefit figures, which are relative to the TSM Alternative).

5.4 Tier 2 Evaluation

In this phase of the Beyond Lechmere Northwest Corridor Study, a number of alternatives were developed at a conceptual level to address the Purpose and Need identified for the project. An initial set of eight Tier 1 alternatives was developed and screened using mainly qualitative indicators to identify a smaller set of alternatives to be explored further. The Tier 1 process and evaluation findings are summarized in Chapter 4 of this report.

In the Tier 2 evaluation, a set of five Build alternatives, a TSM Alternative, and a No-Build Alternative were developed at a slightly greater level of detail. These Tier 2 alternatives are summarized in Section 5.2 of this chapter. Conceptual alignments, operating plans, capital improvement requirements, capital costs, and O&M costs were developed for each alternative. In addition, CTPS modeled the alternatives using the travel demand model for eastern Massachusetts to estimate the ridership, revenue, air quality, environmental justice, and user benefit impacts of each alternative. The CTPS model results are summarized in Section 5.3 of this chapter.

At this stage of evaluation, it was possible to develop a number of quantitative indicators to measure the alternatives against, based on the conceptual operating plans, cost estimates, and the CTPS model results for each alternative. These indicators were developed in five main areas of evaluation: **Environmental, Regional Transit System Capacity, Access to Opportunity, Environmental Justice, and Cost.** Table 5-8 summarizes the quantitative indicators that were developed in each category.

Table 5-8 Summary of Quantitative Indicators Developed for Tier 2 Evaluation

Category	Indicator	Definition
Environmental	Regional Vehicle-Miles of Travel	What is the impact of the proposed alternative on regional Vehicle-Miles of Travel?
	Auto Person-Trips Shifted to Transit	How effective is the proposed alternative in diverting auto person-trips to the transit system?
	Air Quality – Emissions Associated with Highway/Vehicular Travel	What is the impact of the proposed alternative on regional/mesoscale air quality (due to reductions in highway/vehicular travel)?
	Air Quality – Emissions Associated with Increased Transit Service	What is the impact of the proposed alternative on regional/mesoscale air quality? (due to increased transit service)?
Regional Transit System Capacity	Revenue-Vehicle-Hours of Service	How many revenue-vehicle-hours of transit service would be added under the proposed alternative?
	Transit Ridership	How many new linked and unlinked transit trips are generated by the proposed alternative?
Access to Opportunity	System User Benefit	To what extent does the proposed alternative reduce travel times by all travelers in the region?
	Number of Transfers Required	To what extent does the proposed alternative reduce or increase the number of transfers across the transit system?
Environmental Justice	Accessibility of Employment Opportunities	To what extent does the proposed alternative improve access to employment, opportunities for residents of environmental justice target areas?
Cost	Capital Cost	What is the conceptual capital cost of the proposed alternative?
	Operations & Maintenance Cost	What is the conceptual annual O&M cost of the proposed alternative?
	Cost-Effectiveness	How cost-effective is the proposed alternative (in terms of cost per hour of user benefit)?

Most of the quantitative indicators above evaluated based on the conceptual cost estimates for the alternatives or the regional travel demand model results developed by CTPS. However, additional calculations were necessary to develop two of the listed measures, as summarized below:

- **Revenue-Vehicle-Hours of Transit Service**: Revenue-vehicle-hours of service were estimated for each alternative. A revenue-vehicle-hour of service is one hour in which one vehicle is in active service. Revenue-vehicle-hours were calculated based on the estimated travel times, headways, and span of service for each mode of transit service (e.g., Green Line, BRT, commuter rail, or bus) for which service would be added.
- **Cost-Effectiveness**: Cost-effectiveness is calculated by dividing the total annualized cost of an alternative by the total annual hours of user benefit produced by the alternative. Several steps were necessary to estimate the cost-effectiveness of the Tier 2 alternatives:
    - The annualized capital cost was determined by multiplying each main cost item by an annualization factor based on its useful life. Useful life spans are determined by FTA guidelines.

- Annual fare revenue was estimated by multiplying the daily cash fare by an annual factor of 294, and multiplying the result by 70%, a factor which takes into account the use of passes and multiple-ride tickets.
- The incremental annual cost of each alternative was determined by adding the annualized capital cost and the annual O&M cost and subtracting the annual fare revenue.
- Daily user benefit hours were annualized by multiplying the daily figure (from the CTPS model) by a factor of 294.
- Cost per hour of user benefit was determined by dividing the incremental annual cost by the daily hours of user benefit.

Table 5-9 on the next page presents the quantitative indicators for the Tier 2 alternatives. Except where noted, the results in the table show the difference between each alternative and the No-Build Alternative. These results demonstrate how well each alternative meets the Purpose and Need of the proposed project.

Table 5-9 - Comparison of Tier 2 Alternatives - Quantitative Indicators

Indicator	Alt. 1A Green Line to West Medford	Alt. 1C Green Line to West Medford/Union Square	Alt. 2B BRT to West Medford and Green Line to Union Square	Alt. 3A Commuter Rail Shuttle to West Medford	Alt. 3B Commuter Rail Shuttle to Anderson RTC	Alt. 4 Transportation System Management
Operating Characteristics						
A. Headways (Peak Periods)	3 minutes	West Medford Branch: 5 min. Union Square Branch: 7 min.	West Medford Branch: 3 min. Union Square Branch: 3 min.	15 minutes	15 minutes	Medford Hillside Circulator: 20 min. Routes 80, 87, 88, 101: 10 min.
B. Vehicle Requirements	38 Green Line trolleys	32 Green Line trolleys	21 Green Line trolleys; 14 60-foot BRT buses	29 bi-level coaches; 5 locomotives	40 bi-level coaches; 7 locomotives	12 40-foot buses
Environmental						
C. Vehicle Miles of Travel, 2025 (daily, relative to No-Build)	-64,500	-52,800	-50,900	-8,700	-10,000	-6,200
D. Auto Person-Trips Shifted to Transit (daily, relative to No-Build)	13,320	9,660	9,760	1,610	1,830	1,390
Air Quality - Emissions Associated with Highway/Auto Travel						
E. Volatile Organic Compounds (daily kg, relative to No-Build)	-8	-5	-4	-3	-4	-4
F. Nitrous Oxide (daily kg, relative to No-Build)	-18	-14	-2	-3	-3	0
G. Carbon Monoxide (daily kg, relative to No-Build)	-555	-393	-364	-20	-32	-28
Air Quality - Emissions Associated with Added Transit Service						
H. Volatile Organic Compounds (daily kg, relative to No-Build)	Emissions at power plant rather than at vehicle/tailpipe; emissions may vary widely depending on utility fuel mix		0	0	0	0
I. Nitrous Oxide (daily kg, relative to No-Build)			77	19	44	39
J. Carbon Monoxide (daily kg, relative to No-Build)			6	5	9	3
Regional Transit System Capacity						
K. Revenue-Vehicle Hours of Service Added (annual, relative to No-Build)	129,250	101,043	122,281	12,152	18,032	27,612
L. Systwm-Wide Linked Trips, 2025 (daily, relative to No-Build)	14,160	10,060	10,590	1,670	1,890	1,580
M. System-Wide Unlinked Trips, 2025 (daily, relative to No-Build)	9,110	1,600	31,300	2,240	2,560	2,080
Access to Opportunity						
N. Annual Hours of User Benefit, 2025 (relative to TSM)	3,645,600	2,540,160	2,372,580	49,980	67,620	205,800 (relative to No-Build)
O. Transfer Rate, 2025 (System-wide ratio of unlinked trips to linked trips; relative to No-Build)	-0.01	-0.01	0.01	0.00	0.00	0.00
Environmental Justice						
P. Accessibility - Employment Opportunities within 40 minutes by transit (relative to No-Build)						
EJ TAZs in Medford	+6.53%	+5.01%	+3.89%	+1.96%	+2.77%	+1.56%
EJ TAZs in Cambridge	0.00%	0.00%	0.00%	0.00%	0.00%	+2.78%
EJ TAZs in Somerville	+8.43%	+6.24%	+5.65%	+3.07%	+3.50%	+0.94%
Conceptual Costs						
Q. Total Capital Cost (millions of 2005$)	$390.0	$438.0	$340.0	$171.0	$347.0	$4.6
R. Annualized Capital Cost (millions of 2005$)	$29.9	$33.2	$25.4	$13.7	$26.9	$0.6
S. Annual O&M Cost (millions of 2005$)	$9.9	$8.7	$11.1	$3.7	$5.4	$1.8
T. Annual Fare Revenue (millions of 2005$)	$4.9	$3.4	$4.0	$0.6	$1.2	$0.2
U. Incremental Annual Cost (R+S-T)	$35.0	$38.6	$32.5	$16.7	$31.1	$2.2
User Benefit/Cost-Effectiveness						
V. Cost Per Hour of User Benefit, 2025	$9.59	$15.19	$13.70	$334.91	$460.23	$10.54

In addition to the quantitative indicators in the five evaluation areas presented in Table 5-9, it is important to consider the impacts of the proposed alternatives in the other evaluation areas as well. Due to the conceptual nature of this phase of the Beyond Lechmere Northwest Corridor Study, quantitative measures of evaluation were not developed in three areas: **Mobility/Connectivity, Compatibility with Land Use/Economic Development**, and **Constructability**. Each of these areas will be considered in greater detail when the proposed project advances to later phases of project development. However, it is worthwhile to summarize the ratings the Tier 2 alternatives received in each of these areas during the Tier 1 qualitative evaluation process. In the Tier 1 process, each proposed alternative was rated on a scale of **+2 (meets objective/has a positive impact), to -2 (fails to meet objective/has a negative impact)** in each category. Table 5-10 summarizes the Tier 1 ratings in these three categories. Further explanation of these ratings is provided in Appendix A of this report.

Table 5-10 – Summary of Tier 1 Ratings in Qualitative Evaluation Categories

Indicator	Alt. 1A Green Line to West Medford	Alt. 1C Green Line to West Medford and Union Square	Alt. 2B BRT to West Medford and Green Line to Union Square	Alt. 3A Commuter Rail Shuttle to West Medford	Alt. 3B Commuter Rail Shuttle to Anderson RTC	Alt. 4 Transportation System Management
Mobility/Connectivity	+1	+2	+1	+1	Not evaluated in Tier 1	Not evaluated in Tier 1
Comparability with Land Use/Economic Development	+1	+2	+2	+1		
Constructability	+1	+1	+1	+2		

6

Next Steps

This chapter identifies the next steps and areas for further study as the Beyond Lechmere Project progresses into the next stages of the project development process. Considerations that will need to be further studied in the next steps will include Green Line capacity; the location of required support facilities; environmental constraints; station locations; and access considerations.

6.1 Next Steps

The first study phase of this project examined alternatives at a concept level, consistent with FTA guidelines for a Major Investment Study/Alternatives Analysis (MIS/AA). In this phase, questions about the feasibility of alternatives and their relative merits have been addressed in order to narrow the range of alternatives that will be considered in more detail as this project is advanced.

As this project progresses forward, Phase 2 of the study will include the preparation of draft environmental documentation. If the Commonwealth or the MBTA decide to seek Federal funding for the project, the project will follow both the National Environmental Policy Act (NEPA) and Massachusetts Environmental Policy Act (MEPA) processes; this would result in production of a Draft Environmental Impact Statement/Report (DEIS/R). If only State funding is to be used, the project will follow the MEPA process. Efforts in this phase will include:

- Further refine the No-Build, TSM and Build alternatives based on the MIS/AA phase results, including further development of the operational plans for evaluation in the MEPA/NEPA environmental analysis processes.
- Continue to keep the public informed on the development of the project and to obtain public input.
- Perform conceptual engineering of the preferred alternatives, which will include base mapping of the existing conditions of the corridor; design alignments and profiles; station siting and sizing; key structural and civil design elements; and construction staging and sequencing options.

- Develop sufficient baseline environmental information to prepare MEPA/NEPA compliance documents.
- Identify environmental mitigation measures that may be required.
- Prepare refined capital costs and O&M cost estimates based on the conceptual engineering plans and refined schematic operating plans.
- Evaluate the funding and financial requirements for the project.
- Prepare the required environmental documentation (i.e. Draft EIS/R).

Once Phase 2 of the study is completed, this project will move into Preliminary Engineering and development of the Final EIS/R. Work during this phase will include further development of the engineering design (including systems design), preparation of the Final EIS/R, and further refinement of the project costs.

6.2 Areas for Further Study

As this project moves into the next stages of project development, there are a number of determinations that will need to be made and key areas that will need to be further explored. Some of these considerations include, but are not limited to, the following:

- **Conceptual Design of Alternatives**: In the next phases of this study, conceptual design and preliminary design of the proposed alternative(s) will occur, allowing more specific conclusions to be drawn about operational requirements, potential environmental impacts, and costs. Design plans will be developed, survey information will be collected, and specific engineering constraints (such as existing structures and potential grade crossing impacts at High Street and Canal Street) will be examined in detail.

- **Operating Plans:** In this study phase, it was assumed that existing Green Line service at Lechmere would be extended northwest through the Study Area, without extending additional Green Line branches northwest from Lechmere or adjusting headways on the individual branches. This allowed for an even comparison of alternatives in this stage of study. In the next phase, it will be necessary to better define a specific operating plan for each service type. These operating plans could include extensions of additional branches, adjustments to headways, or a combination of both. The refined operating plans will need to consider specific station locations, projected ridership, fare collection methods and infrastructure, as well as potential impacts on existing transit services.

- **Lechmere Station**: As noted in Chapter 3 of this report, Lechmere Station is proposed to be relocated to the east side of the McGrath Highway under a partnership agreement with Guilford Transportation and the North Point developers. Plans for the new station will improve passenger and bus flow at the station. Design of the station will be proceeding as the developer obtains project financing; permits for the North Point development project have been obtained from the City of Cambridge. However, to date the Lechmere Station plans have not directly taken into account the possible alternatives for the Beyond Lechmere project. This could pose a particular problem for Alternative 2B, because of the large number of BRT riders from the Study Area who would disembark and transfer to Green Line vehicles at Lechmere Station. Further coordination of the Beyond Lechmere project and the Lechmere Station design will be necessary in the next phase of this study.

- **Green Line Impacts:** In this phase, Tier 2 Alternatives 1A, 1C, and 2B considered the possibility of extending Green Line service to new markets northwest of Lechmere. Based on the conceptual alignments and operating plans that were developed, it was assumed that these alternatives were feasible from an operational perspective. This was considered to be a reasonable assumption because the conceptual operating plans extended the current Green Line branches that serve Lechmere Station and maintained the existing headways on each branch. A comprehensive operational analysis will need to be undertaken in Phase 2 of the study to ensure that the planned extension does not adversely impact the existing Green Line service. Further study will be required to ensure that the vehicles in the Central Subway are capable of accommodating the potential additional riders that would be introduced by the extension. Other considerations will also include:
    - Identification of the new and required upgrades to the power systems that would be necessary to accommodate the service.
    - Identification of new signal systems and determination of the extent of any other signal upgrades that would be required.
    - Consideration of improvements to the MBTA's trolley priority system on the surface branches to better control the operations of the branch lines beyond Lechmere.

- **Impacts on Existing Structures**: As noted in Chapter 5, implementation of one of the Build Alternatives will require the reconstruction of a number of existing structures. These include existing bridges along the Lowell and Fitchburg commuter rail lines. Further study will be required to identify which bridges will need to be reconstructed, estimate the capital costs of the reconstruction, and develop a strategy for coordination of the reconstruction work. This effort will also need to identify any right-of-way requirements associated with the reconstruction of existing structures. Special attention will also need to be given to the viaduct between Science Park Station and Lechmere Station. Train speeds are currently limited to 10 miles per hour on the viaduct. Renovation work is currently planned on the viaduct, but a full assessment will be necessary to evaluate its ability to handle the loads associated with the planned extension and to identify any additional required improvements.

- **Right-of-Way Requirements**: Several of the Build alternatives considered in the Tier 2 evaluation will likely require some right-of-way acquisition. As noted in Chapter 5, right-of-way acquisition may be necessary to construct the track and stations along the Fitchburg Line between Lechmere and Union Square, and along portions of the Lowell Line north of College Avenue. Additional right-of-way may be required for the construction of a vehicle maintenance and storage facility within the study area, as described below. These right-of-way requirements will need to be identified more specifically and considered among the project's environmental impacts and costs as the study progresses.

- **BRT capacity**: The conceptual operating plan for Alternative 2B, which would provide BRT service to West Medford and Green Line service to Union Square, assumed three-minute headways on the BRT segment of the alignment. These headways were established to allow a comparison of Alternative 2B with Alternatives 1A and 1C at similar levels of service. Based on the ridership results for Alternative 2B from the CTPS travel demand model, it appears possible that the BRT segment might not be capable of handling the projected ridership given the headways and assumed vehicle capacities. If this alternative is progressed, further study of the BRT capacity and operating parameters would be necessary.

- **Station Siting and Sizing**: The number and approximate locations of the proposed stations were identified during this stage for operational planning purposes. Specific station locations, sizing and layouts were not identified. In the next phase of this project, station sites and designs will be further developed and consideration will be given to elements such as station access, parking, environmental impacts, and potential right-of-way needs. As these topics are addressed in the next study phase, consideration can also be given to the connection between station-area land uses, development issues, and station locations.

- **Determination of Terminus Point**: The conceptual alignments and operating plans for alternatives 1A, 1C, and 2B assumed that the extension would terminate in West Medford, west of the Mystic River but east of the High Street grade crossing. In the next study phase, a determination will need to be made as to the exact terminus point in West Medford of the preferred alternative.

- **Fleet Identification and Procurement**: The number of vehicles required for each Tier 2 Build alternative was estimated based on the preliminary operating plans and services developed at this stage of study. As this project progresses and operating plans are further refined, identification of the number of additional vehicles necessary for the preferred alternative(s) will be performed. A thorough understanding of the existing fleet and the future fleet without the extension will also be necessary to develop a vehicle procurement strategy to operate the extension and maintain the existing service. Following the development of this strategy, implementation steps will include designing the vehicle specifications and initiating the vehicle procurement process. The time required to develop the vehicle specification designs and undertake procurement could take several years; therefore, the fleet sizing, design and procurement process will likely be a critical path item in setting a project schedule.

- **Vehicle Storage and Maintenance Capacity**: Each of the Build alternatives, as well as the TSM alternative, would result in the introduction of additional vehicles to the MBTA system because of the extra service offered. These additional vehicles will require increases in storage and maintenance capacity, whether through the construction of a new facility or expansion of an existing location. The locations of these support facilities were not identified in this study phase due to the conceptual nature of the analysis; therefore this is an area that will require further examination in the next phase. For the purposes of this study, it was assumed that the Green Line alternatives would require a storage and maintenance facility to accommodate the expanded Green Line fleet. This facility may be similar in size and function to the MBTA's Riverside facility on the D Branch of the Green Line. The new facility would likely include a car-house with pits, joists, a wheel truing machine, and a car wash facility, as well as a yard to store approximately 70 vehicles. In the next study phase, it will be necessary to further identify the components to be included in the maintenance facility, determine potential locations, and identify any land takings that would be necessary.

- **Potential Environmental Impacts:** As this project progresses, it will be necessary to identify and explore potential environmental impacts of the project, and to address them through the appropriate environmental review process. As noted previously, this will involve either the MEPA process alone or a combined MEPA/NEPA process depending on the project funding source.

- **Cost Estimates and Financial Analysis:** In this study phase, the potential cost implications of the Tier 2 alternatives were considered at a conceptual level to provide a basis for comparison. Capital and O&M costs were developed and will be refined as the alternatives are further developed and their cost elements are better defined. Careful consideration to the long-term impacts on systemwide operating and maintenance costs will need to be addressed. Additionally, a detailed financial analysis including projections of project cash flow over a 20-year time horizon and consideration of potential funding sources will need to be undertaken in the next phase of the study. If Federal New Starts funding is pursued for the project, a complete FTA New Starts Financial Analysis will need to be completed as the project progresses.

Appendices

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Appendix A

Tier 1 Detailed Evaluation Tables

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Green Line - Alternative 1A				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
1A – Green Line Extension to West Medford	This alternative would provide an extension of the Green Line from Lechmere northwards along the MBTA's Lowell Line terminating in the vicinity of the existing West Medford commuter rail station.	Environmental	1	▪ Moderate air quality benefits; ▪ Moderate impacts on Mystic River; ▪ Minor right-of-way (ROW) impacts; ▪ Minor storm drainage impacts.
		Regional Transit System Capacity	1	▪ Improved reliability in dedicated corridor; ▪ Constraints on Green Line Central Subway capacity.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	1	▪ Multimodal connections (bus, commuter rail) at intermediate stations; ▪ Links neighborhoods within study area; ▪ Does not serve major Union Square hub.
		Compatibility with Land Use	1	▪ Compatible with existing land uses; ▪ Compatible with local plans, except does not serve Union Square redevelopment area.
		Environmental Justice	2	▪ Transportation benefits to EJ communities include improvements to service quality and reliability; ▪ Makes use of existing transportation corridor with minimal adverse impact on neighborhoods; ▪ Layover facility to be located in existing industrial area.
		Cost	0	▪ Located within existing corridor and ROW; ▪ Moderate capital costs associated with track and systems, a new yard, and bridge improvements; ▪ Traffic mitigation (i.e. grade separation) costs in West Medford.
		Constructability	1	▪ Located within existing corridor and ROW; ▪ Construction will not impact existing Green Line or commuter rail services; ▪ Impacts to local traffic on street and bridge improvements.
		TOTAL SCORE	**9**	

Green Line - Alternative 1B				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
1B - Green Line Extension to West Medford via Union Square	This alternative would provide an extension of the Green Line from Lechmere westward to Union Square along the MBTA's Fitchburg Line into Union Square, then northwards via a new deep bore tunnel under Union Square and Prospect Hill, and join the Lowell Line right-of-way near School Street. The route would then continue northwards to West Medford.	Environmental	-1	▪ Moderate air quality benefits; ▪ Moderate impacts on Mystic River; ▪ Minor right-of-way (ROW) impacts; ▪ Minor storm drainage impacts; ▪ Noise, vibration, and ventilation impacts of tunnel.
		Regional Transit System Capacity	1	▪ Improved reliability in dedicated corridor; ▪ Constraints on Green Line Central Subway capacity.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	2	▪ Multimodal connections at intermediate stations; ▪ Links neighborhoods within study area; ▪ Serves major Union Square hub.
		Compatibility with Land Use	2	▪ Compatible with existing land uses; ▪ Compatible with local plans, including Union Square Master Plan TOD.
		Environmental Justice	1	▪ Transportation benefits to EJ communities include improvements to service quality and reliability; ▪ Additional benefit of Union Square service and access to more EJ communities; ▪ Makes use of existing transportation corridor along Lowell Line, but with adverse impact on neighborhoods with tunnel to Union Square; ▪ Layover facility to be located in existing industrial area.
		Cost	-2	▪ Uses existing corridor and ROW, but some ROW would need to be acquired. ▪ Moderate capital costs associated with track and systems, a new yard, and bridge improvements; ▪ Significant capital cost for tunnel construction and operating costs for tunnel maintenance; ▪ Traffic mitigation costs in West Medford.
		Constructability	-2	▪ Located within existing corridor and ROW, with some ROW acquisition and impact on local area; ▪ Construction will not impact existing Green Line or commuter rail services; ▪ Impacts to local traffic on street and bridge improvements; ▪ Tunnel construction under developed neighborhoods; ▪ Relocation of utilities.
		TOTAL SCORE	**3**	

Green Line - Alternative 1C

Alternative	Description	Criterion	Score	Explanation
1C - Green Line Extension to West Medford and to Union Square	This alternative would provide Green Line service to Union Square and West Medford via a two-branch operation. One branch would operate from Lechmere to West Medford along the Lowell Line as per Alternative 1A. The second branch would operate along the Fitchburg Line from Lechmere into a terminus at Union Square. *(A variant to this alternative includes extending the Green Line to Porter Square. This variant can be further explored in Tier 2.)*	Environmental	1	▪ Moderate air quality benefits; ▪ Moderate impacts on Mystic River; ▪ Minor right-of-way (ROW) impacts; ▪ Minor drainage impacts.
		Regional Transit System Capacity	0	▪ Improved reliability in dedicated corridor; ▪ Constraints on Green Line Central Subway capacity; ▪ Produces longer headways on each branch due to split service.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	2	▪ Multimodal connections at intermediate stations; ▪ Links neighborhoods within study area; ▪ Parallels both commuter rail lines. ▪ Serves major Union Square hub.
		Compatibility with Land Use	2	▪ Compatible with existing land uses; ▪ Compatible with local plans, including Union Square Master Plan TOD.
		Environmental Justice	2	▪ Transportation benefits to EJ communities include improvements to service quality and reliability; ▪ Additional benefit of Union Square service and access to more EJ communities; ▪ Makes use of existing transportation corridor along Lowell Line; ▪ Layover facility to be located in existing industrial area.
		Cost	0	▪ Uses existing corridor and ROW, but some ROW would need to be acquired. ▪ Moderate capital costs associated with track and systems, a new yard, and bridge improvements; ▪ Traffic mitigation (i.e. grade separation) costs in West Medford.
		Constructability	1	▪ Located within existing corridor and ROW; ▪ Construction will not impact existing Green Line or commuter rail services; ▪ Impacts to local traffic on street and bridge improvements.
		TOTAL SCORE	**10**	

Green Line - Alternative 1D				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
1D - Green Line Extension to Union Square with Commuter Rail Station Stops to West Medford	This alternative would provide an extension of the Green Line from Lechmere west to Union Square along the MBTA's Fitchburg Line. This alternative would also construct two new commuter rail stations on the Lowell Line to West Medford. It should be noted that a third commuter rail station is proposed at Gilman Square as part of the Urban Ring Project. Stations will be served by regularly scheduled Lowell Line trains. *(A variation of this alternative includes extending the Green Line to Porter Square.*	Environmental	1	▪ Moderate air quality benefits; ▪ No additional impacts on Mystic River; ▪ Minor right-of-way (ROW) impacts; ▪ Noise, vibration, and emission impacts from commuter rail diesel locomotives.
		Regional Transit System Capacity	0	▪ Improved reliability in dedicated corridor; ▪ Moderate impacts on existing commuter rail service; ▪ Impacts on commuter rail capacity (overcrowding, additional run-time); ▪ Improved reliability and capacity on Green Line segment to Union Square; ▪ Constraints on Green Line Central Subway capacity.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	1	▪ Requires a transfer at North Station; ▪ Serves Union Square and North Station hubs; ▪ Several multimodal connections; ▪ Links neighborhoods within study area.
		Compatibility with Land Use	2	▪ Compatible with existing land uses; ▪ Compatible with local plans, including Union Square Master Plan TOD.
		Environmental Justice	1	▪ Transportation benefits to EJ communities include replacement of bus services, and improvements to service quality and reliability; ▪ Additional benefit of Union Square service and access to more EJ communities; ▪ Makes use of existing transportation corridors; ▪ Layover facility to be located in existing industrial area.
		Cost	1	▪ Uses existing corridor and ROW; ▪ Moderate capital costs associated with track and systems, a new yard, and stations; ▪ Traffic mitigation costs in West Medford.
		Constructability	-2	▪ Located within existing corridor and ROW; ▪ Construction will not impact existing Green Line; ▪ Impacts to local traffic on street improvements; ▪ Major impacts on existing commuter rail and freight services.
		TOTAL SCORE	**6**	

Bus Rapid Transit - Alternative 2A				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
2A- BRT Lechmere to West Medford	This alternative would replicate Alternative 1a, using high capacity buses operating on a two-lane paved roadway within the railroad corridor. The Bus Rapid Transit (BRT) mode could alleviate the Green Line related grade crossing concerns at West Medford by using public streets in this area.	Environmental	0	▪ Moderate air quality benefits; ▪ Minor right-of-way (ROW) impacts; ▪ Substantial storm drainage impacts (closed system, more impervious surface, discharge, salt in winter).
		Regional Transit System Capacity	0	▪ Improved reliability in dedicated corridor; ▪ Flexibility in operations; ▪ Limited by Green Line Central Subway capacity with transfer at Lechmere.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	0	▪ Multimodal connections at intermediate stations; ▪ Links neighborhoods within study area; ▪ Does not serve major Union Square hub; ▪ Transfer to access downtown required.
		Compatibility with Land Use	1	▪ Compatible with existing land uses; ▪ Compatible with local plans, but does not serve Union Square redevelopment area.
		Environmental Justice	1	▪ Transportation benefits to EJ communities include improvements to service quality and reliability; ▪ Makes use of existing transportation corridor along Lowell Line; ▪ No layover facility impact on neighborhoods.
		Cost	1	▪ Primarily uses existing corridor and ROW; ▪ Infrastructure costs limited to pavement and bridge improvements; ▪ No new yard or traction power costs; ▪ Traffic mitigation costs in West Medford.
		Constructability	1	▪ Located within existing corridor and ROW; ▪ Construction will not impact existing Green Line or commuter rail services; ▪ Impacts to local traffic on street and bridge improvements.
		TOTAL SCORE	**6**	

Bus Rapid Transit - Alternative 2B				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
2B - BRT Lechmere to West Medford with Green Line to Union Square	This alternative would combine Alternative 2a and Alternative 1c. High capacity buses would operate on a two-lane paved roadway within the railroad corridor to West Medford. A Green Line segment would operate along the Fitchburg Line from Lechmere into a terminus at Union Square. A variant to this alternative is to have both legs BRT. This variant can be further explored in Tier 2.	Environmental	0	▪ Moderate air quality benefits; ▪ Minor right-of-way (ROW) impacts; ▪ Substantial storm drainage impacts (closed system, more impervious surface, discharge, salt in winter).
		Regional Transit System Capacity	1	▪ Improved reliability in dedicated corridor; ▪ Some flexibility in operations; ▪ Capacity enhanced by Green Line service to Union Square; ▪ Limited by Green Line Central Subway capacity with transfer at Lechmere.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	1	▪ Serves major Union Square hub; ▪ Multimodal connections at intermediate stations; ▪ Links neighborhoods within study area.
		Compatibility with Land Use	2	▪ Compatible with existing land uses; ▪ Compatible with local plans, including Union Square Master Plan TOD.
		Environmental Justice	2	▪ Transportation benefits to EJ communities include improvements to service quality and reliability; ▪ Additional benefit of Union Square service; ▪ Makes use of existing transportation corridors; ▪ No layover facility impact on neighborhoods.
		Cost	1	▪ Primarily uses existing corridor and ROW; ▪ Infrastructure costs include track and systems on Green Line segment; ▪ Pavement costs on BRT segment; ▪ Bridge improvements; ▪ No new bus yard; ▪ Green Line yard required; ▪ Traffic mitigation costs in West Medford.
		Constructability	1	▪ Located within existing corridor and ROW; ▪ Construction will not impact existing Green Line or commuter rail services; ▪ Impacts to local traffic on street and bridge improvements.
		TOTAL SCORE	**10**	

Bus Rapid Transit - Alternative 2C				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
2C – BRT Lechmere to West Medford via Union Square with Green Line to Yard 8	This alternative would provide BRT service from Lechmere to Union Sq. along the Fitchburg Line and Somerville Avenue, in a loop-type alignment. A new busway would be between Somerville Avenue and the Fitchburg Line. Beyond Union Square, BRT would utilize public streets to reach the Lowell Line at Gilman Square. The route would then utilize the Lowell Line right-of-way north to West Medford. Green Line would be extended north from Lechmere to "Yard 8", providing the opportunity for a station near Washington St.	Environmental	0	▪ Moderate air quality benefits; ▪ Minor right-of-way (ROW) impacts; ▪ Substantial storm drainage impacts (closed system, more impervious surface, discharge, salt in winter).
		Regional Transit System Capacity	1	▪ Improved reliability in dedicated corridor; ▪ Some flexibility in operations; ▪ Capacity enhancements; ▪ Limited by Green Line Central Subway capacity.
		Access to Opportunity	2	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	0	▪ Serves major Union Square multi-modal hub, but in mixed traffic operations; ▪ Multimodal connections at intermediate stations; ▪ Links neighborhoods within study area.
		Compatibility with Land Use	1	▪ Compatible with existing land uses; ▪ Somewhat compatible with local plans; provides improved transit but not Green Line service as envisioned in Union Square Master Plan.
		Environmental Justice	0	▪ Transportation benefits to EJ communities including improving service quality and reliability; ▪ Additional benefit of Union Square service, but associated local traffic impacts; ▪ Makes use of existing transportation corridors; ▪ Layover facility impact in industrial area.
		Cost	1	▪ Primarily uses existing corridor and ROW; ▪ Infrastructure costs include track and systems on Green Line segment only to Washington St.; ▪ Pavement costs on BRT segments; ▪ Bridge improvements; ▪ No new bus yard, but Green Line yard required; ▪ Traffic mitigation costs.
		Constructability	1	▪ Located within existing corridor and ROW; ▪ Construction will not impact existing Green Line or commuter rail services; ▪ Impacts to local traffic on street and bridge improvements, especially at Union Square.
		TOTAL SCORE	**6**	

Bus Rapid Transit - Alternative 2D				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
2D - BRT Lechmere to Union Square with Commuter Rail Station Stops to North Station	This alternative would provide a Bus Rapid Transit (BRT) service from Lechmere to Union Square along the MBTA's Fitchburg Line. Additionally, this alternative would construct two new commuter rail station stops on the Lowell Line to West Medford. It should be noted that a third commuter rail station is proposed at Gilman Square as part of the Urban Ring Project. Stations will be served by regularly scheduled Lowell Line trains.	Environmental	0	▪ Moderate air quality benefits; ▪ No additional impact on Mystic River; ▪ Substantial drainage impacts (closed system, more impervious surface, discharge, salt in winter); ▪ Noise, vibration and emissions impacts from commuter rail diesel locomotives. ▪ Minor ROW impacts.
		Regional Transit System Capacity	-1	▪ Improved reliability in dedicated corridor; ▪ Some flexibility in operations; ▪ Impacts on existing commuter rail service and capacity; ▪ Limited by Green Line Central Subway capacity once passengers transfer at Lechmere.
		Access to Opportunity	1	▪ Access to downtown Boston; ▪ Access to jobs, educational, institutional destinations in the study area.
		Mobility/ Connectivity	1	▪ Serves major Union Square and North Station multi-modal hubs; ▪ Multi-modal connections.
		Compatibility with Land Use	1	▪ Compatible with existing land uses; ▪ Supports TOD plans near Union Square, and provides improved transit but not Green Line service as envisioned in Union Square Master Plan.
		Environmental Justice	1	▪ Transportation benefits to EJ communities including improving service quality and reliability; ▪ Additional benefit of Union Square service; ▪ Makes use of existing transportation corridors; ▪ No layover facility impact on neighborhoods.
		Cost	2	▪ Uses existing corridor and ROW; ▪ Infrastructure costs include pavement, track systems and station costs; ▪ No new bus or layover yard; ▪ Minor traffic mitigation costs.
		Constructability	-2	▪ Located primarily within existing ROW; ▪ Construction will not impact existing Green Line; ▪ Impacts to local traffic on street improvements, especially at Union Square; ▪ Major impacts on existing commuter rail and freight services
		TOTAL SCORE	**3**	

Commuter Rail - Alternative 3				
Alternative	**Description**	**Criterion**	**Score**	**Explanation**
3 –Commuter Rail Shuttle Service to West Medford	This alternative would provide more frequent commuter rail service and additional stations on the Lowell Line through Somerville to West Medford. Operations would include the use of a shuttle train operating from North Station to West Medford. An additional track or a series of passing sidings may need to be constructed in the right-of-way to accommodate the service.	Environmental	1	▪ Some air quality benefits; ▪ Noise, vibration, emissions impacts from commuter rail diesel locomotives; ▪ Minor ROW impacts; ▪ No additional impact on Mystic River crossing.
		Regional Transit System Capacity	1	▪ Improved reliability in dedicated corridor; ▪ Improved commuter rail capacity; ▪ Impacts on existing commuter rail service;
		Access to Opportunity	1	▪ Access to downtown Boston; ▪ Access to jobs, educational, and institutional destinations along the study corridor.
		Mobility/ Connectivity	1	▪ Serves multi-modal connections at North Station; ▪ Links neighborhoods along Lowell Line within study area.
		Compatibility with Land Use	1	▪ Compatible with existing land uses; ▪ Not compatible with local plan to service Union Square.
		Environmental Justice	1	▪ Transportation benefits to EJ communities including removing buses, improving service quality and reliability; ▪ Makes use of existing transportation corridor; ▪ No impact of layover facility.
		Cost	1	▪ Uses existing corridor; ▪ Commuter rail uses existing infrastructure, requires new third track, sidings, systems and high-level platforms; ▪ Some bridge improvements required.
		Constructability	2	▪ Located primarily within existing ROW; ▪ Construction will have minor impacts on existing commuter rail services; ▪ Commuter rail can use existing infrastructure and is consistent with existing system/technology.
		TOTAL SCORE	**9**	

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Appendix B

Locus Maps of Proposed Station Areas

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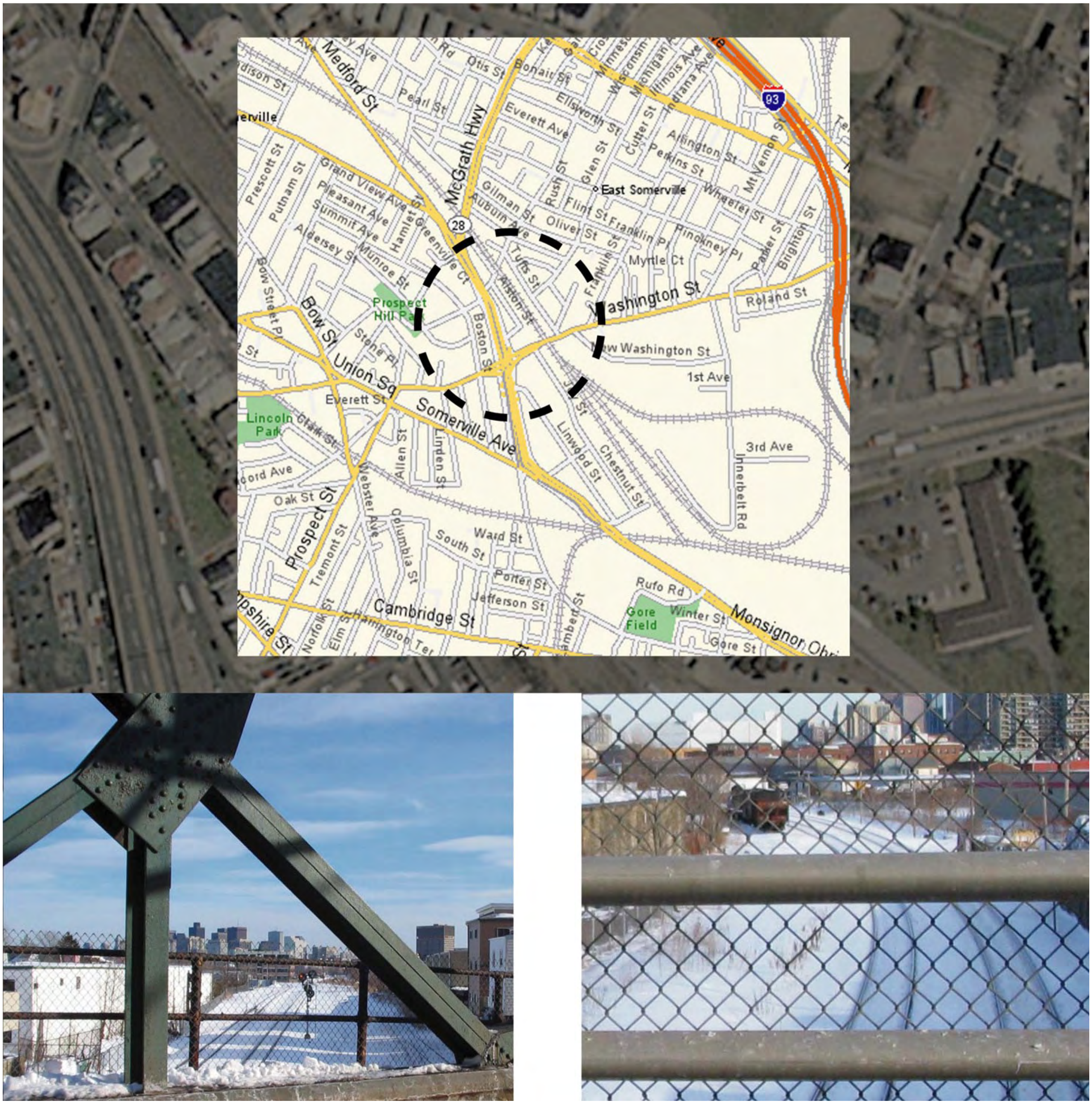
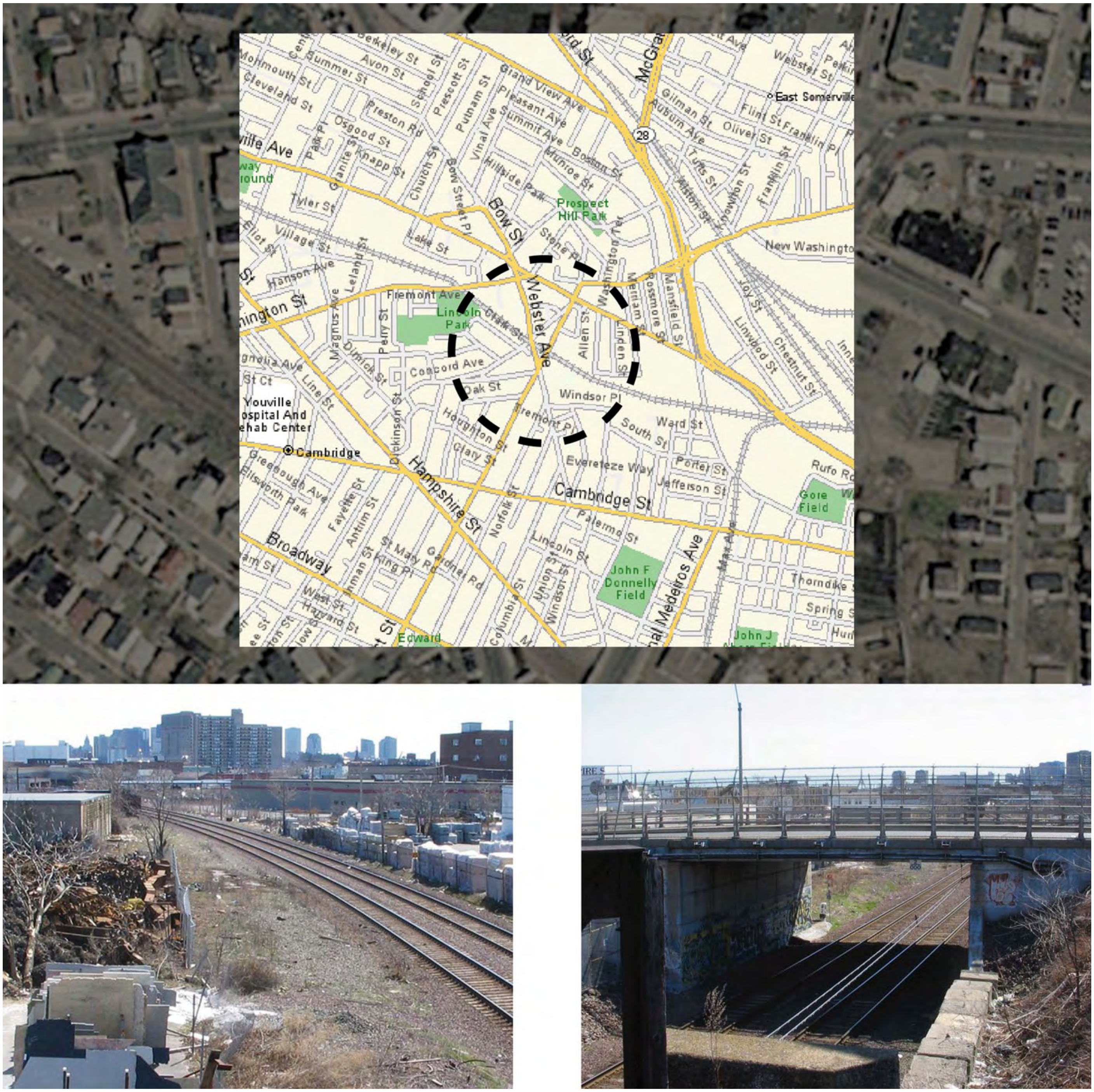


Beyond Lechmere Northwest Corridor Study

Figure B-1

Proposed Washington Street Station
Locus Map

Massachusetts
Bay
Transportation
Authority

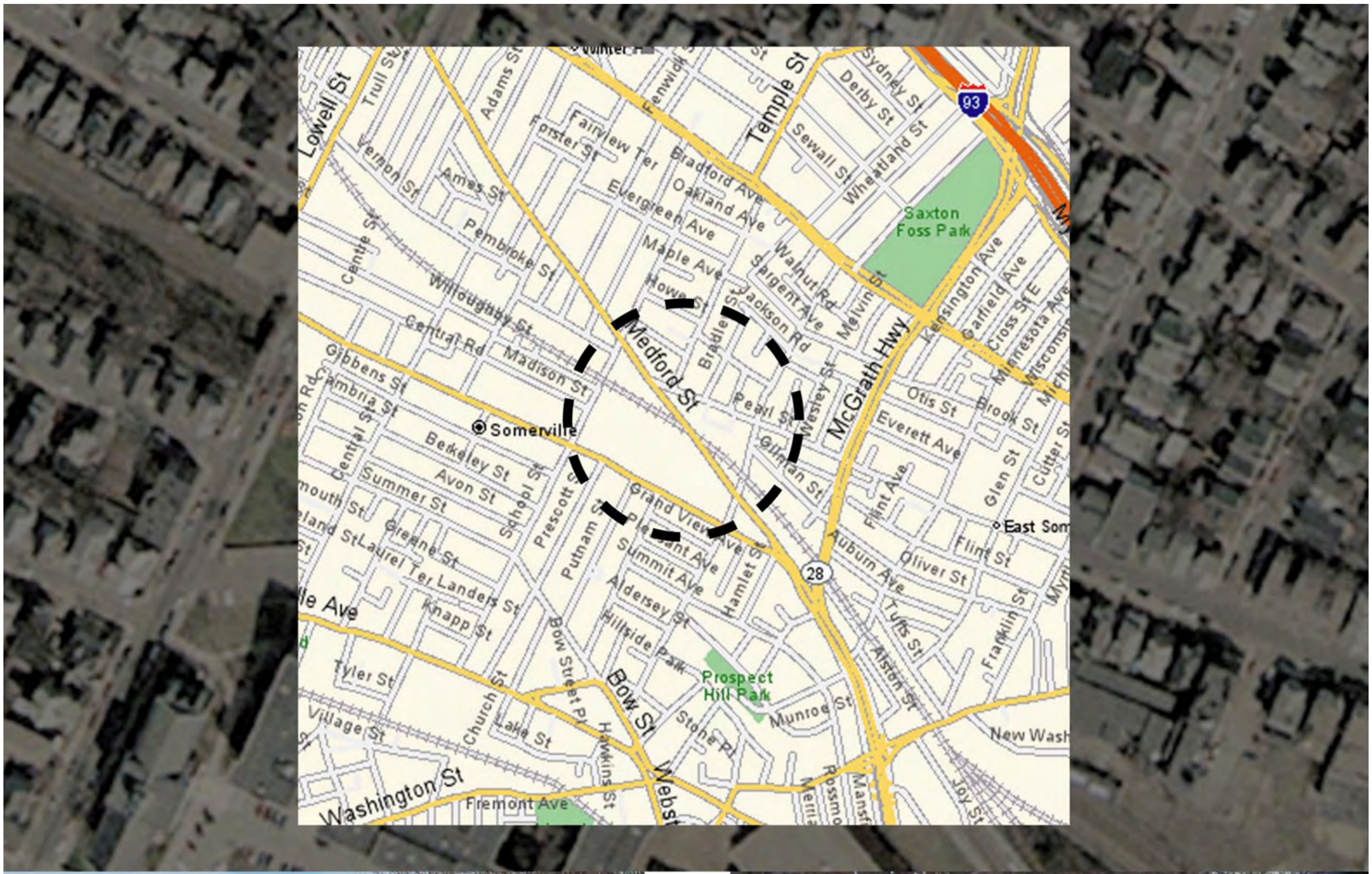


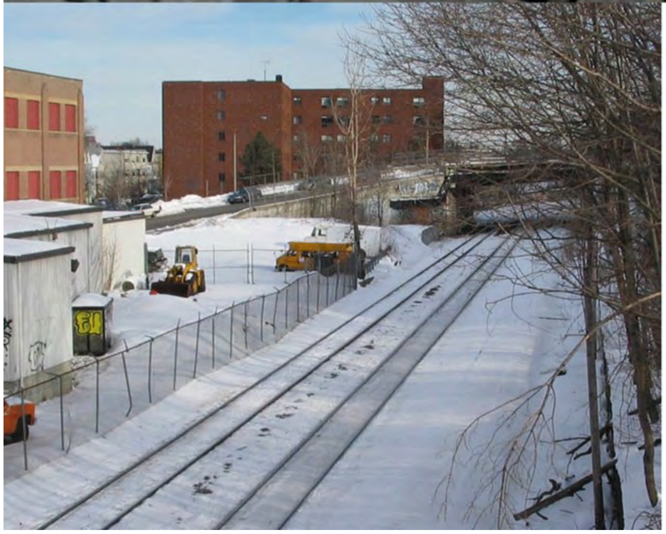
Beyond Lechmere Northwest Corridor Study

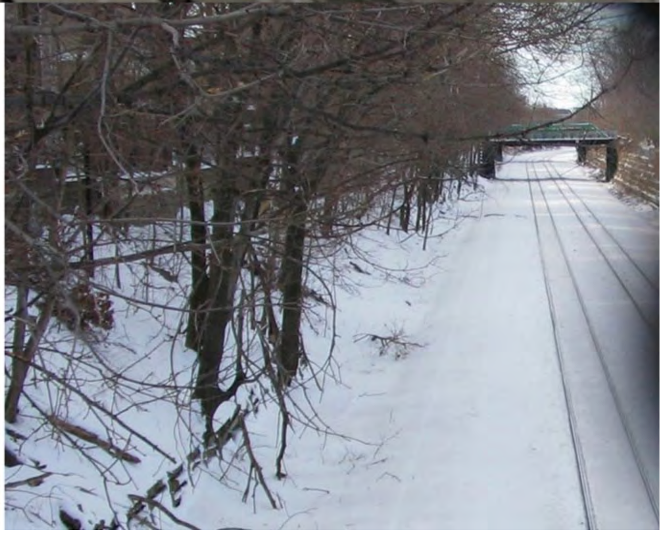
Figure B-2

Proposed Union Square Station
Locus Map

**Massachusetts
Bay
Transportation
Authority**





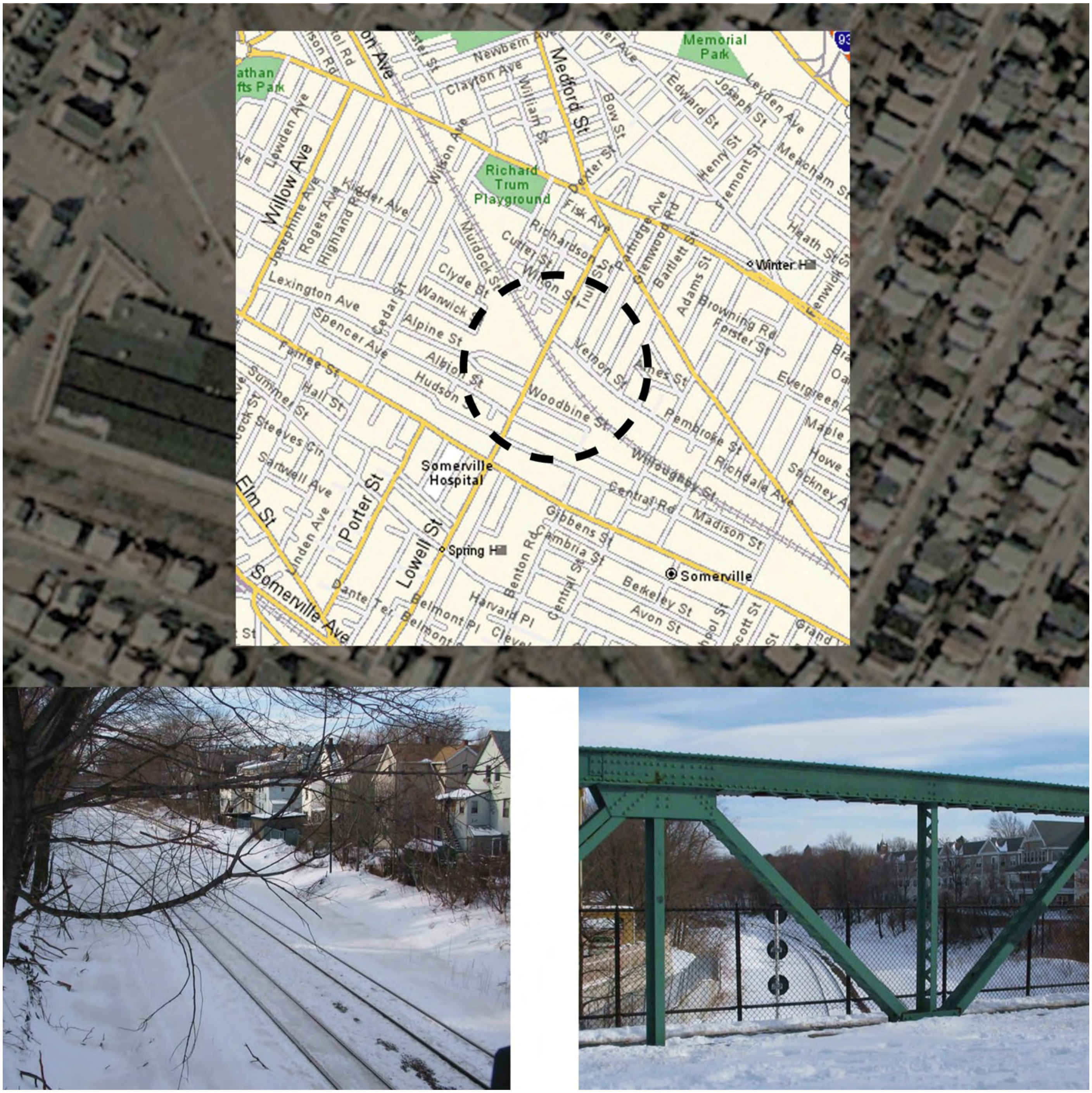


Massachusetts
Bay
Transportation
Authority

Beyond Lechmere Northwest Corridor Study

Figure B-3

Proposed Gilman Square Station Locus Map

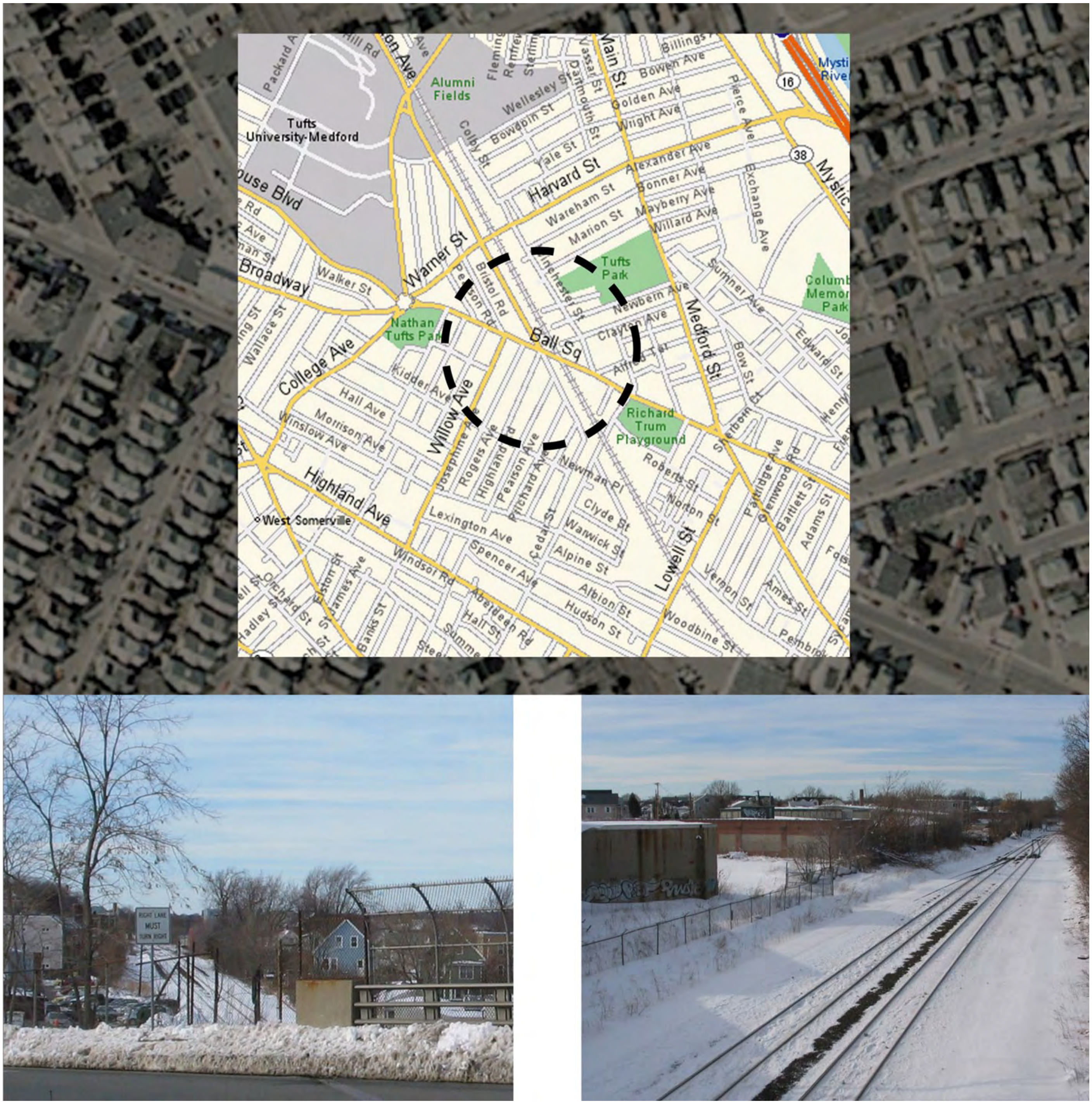


Beyond Lechmere Northwest Corridor Study

Figure B-4

Proposed Lowell Street Station
Locus Map

Massachusetts
Bay
Transportation
Authority

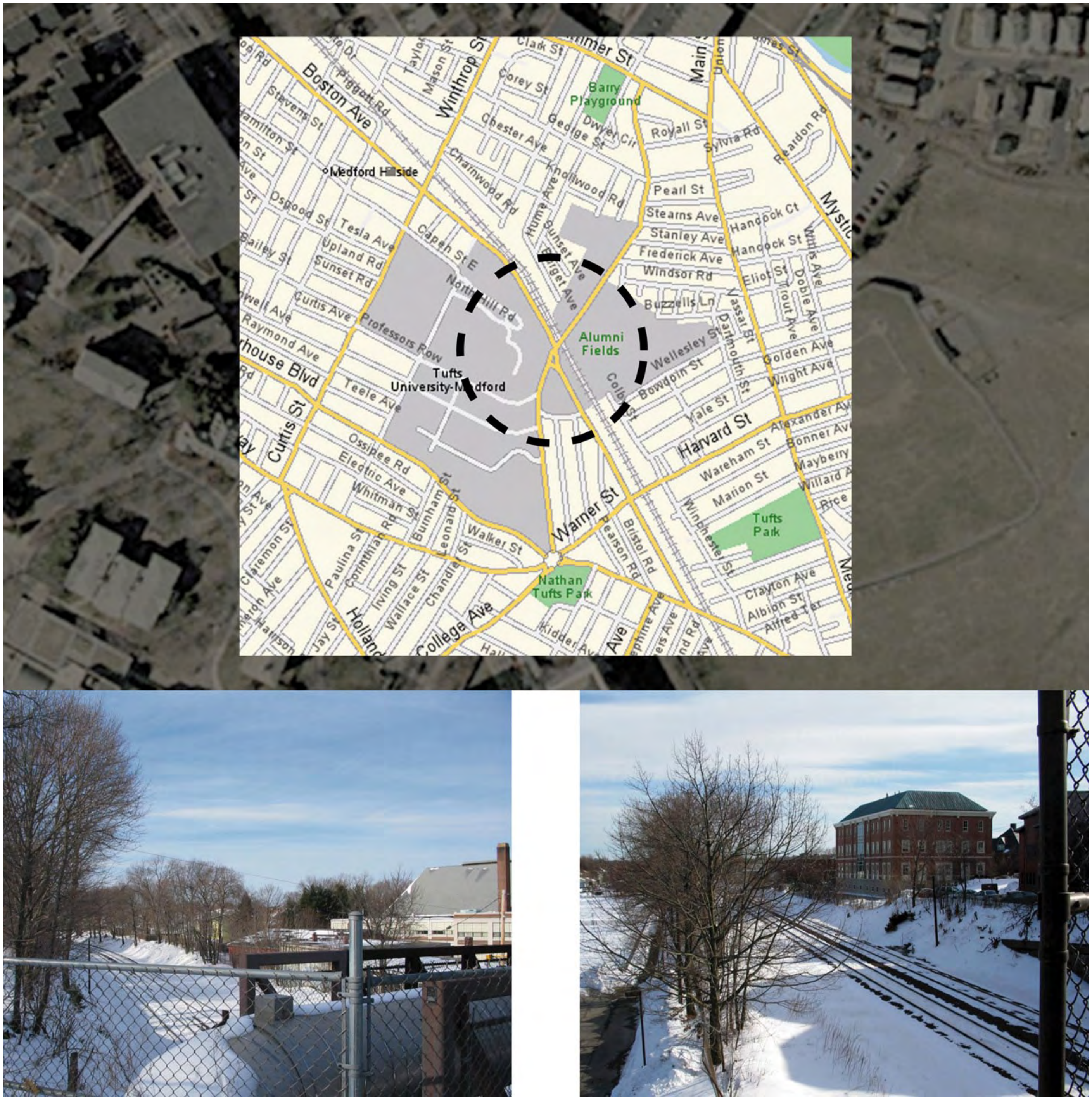


Beyond Lechmere Northwest Corridor Study

Figure B-5

Proposed Ball Square Station
Locus Map

Massachusetts
Bay
Transportation
Authority

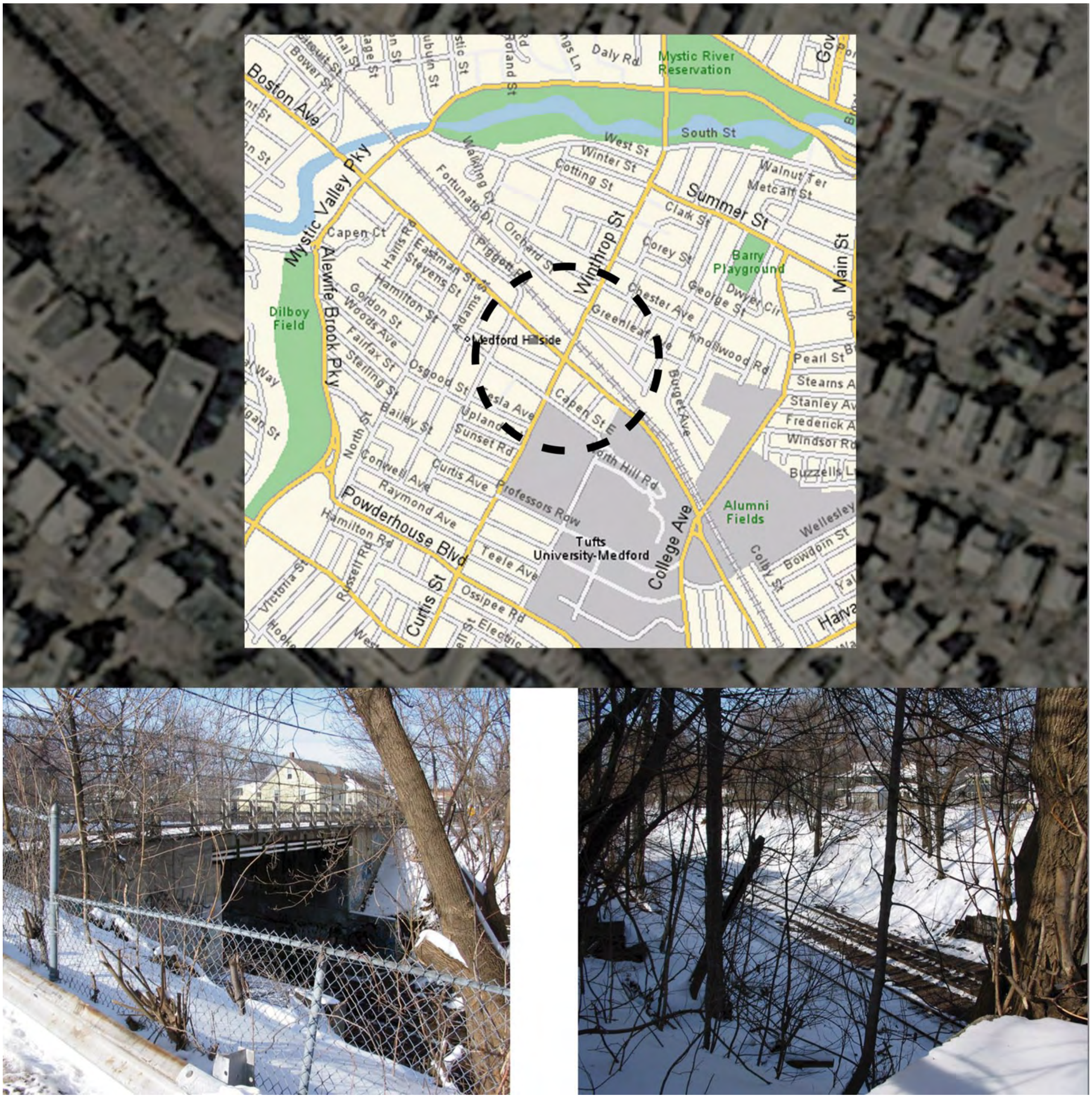


Beyond Lechmere Northwest Corridor Study

Figure B-6

Proposed College Avenue Station
Locus Map

**Massachusetts
Bay
Transportation
Authority**

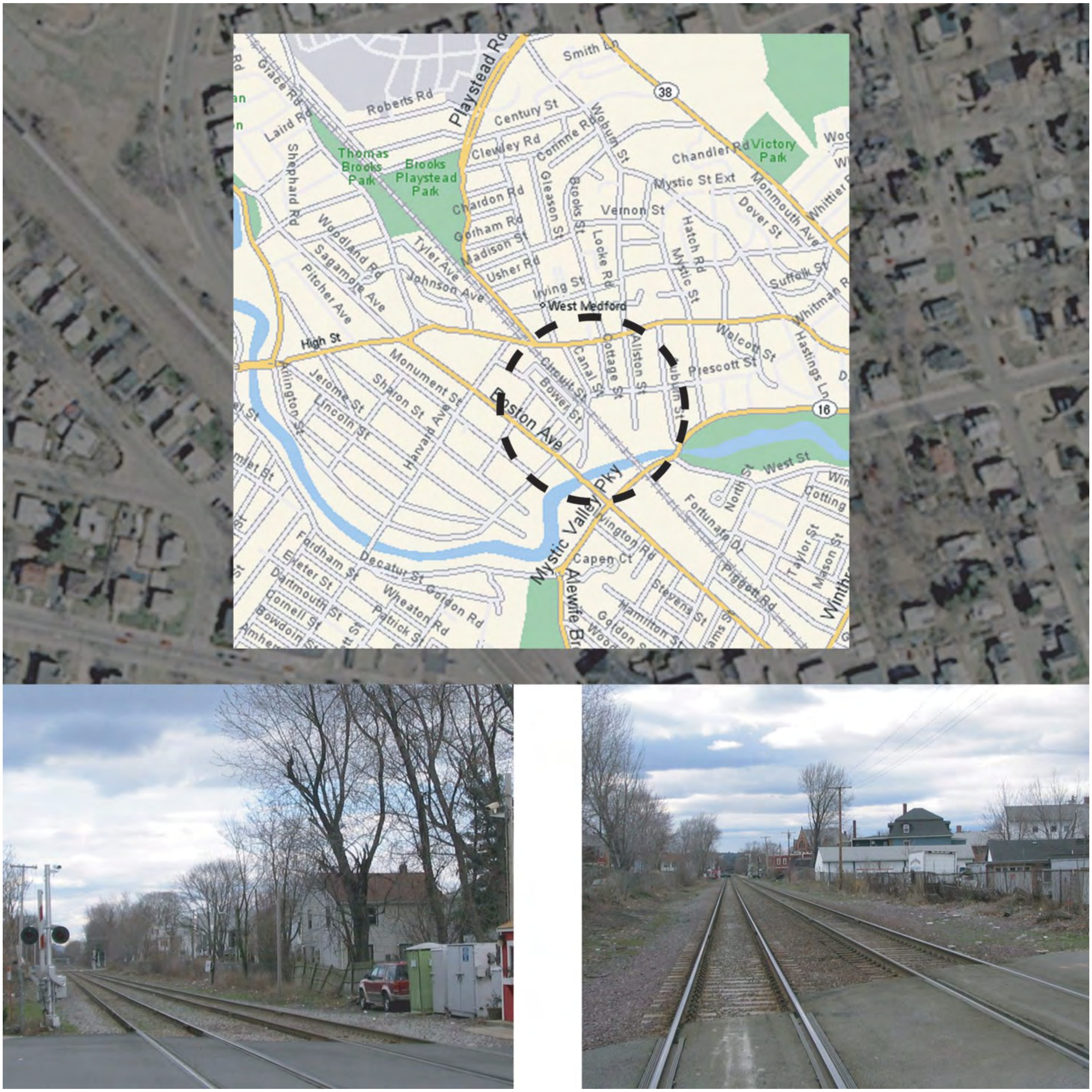


Beyond Lechmere Northwest Corridor Study

Figure B-7

Proposed Winthrop Street Station
Locus Map

**Massachusetts
Bay
Transportation
Authority**



Beyond Lechmere Northwest Corridor Study

Figure B-8

Proposed West Medford Station Locus Map

Massachusetts Bay Transportation Authority

Appendix C

Conceptual Capital Cost Estimate Detail

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Major Capital Project Costs - Main Worksheet (Rev. 1, Jan. 21, 2005)

Project	**Beyond Lechmere**	Today's Date	**3/29/05**
Location	Cambridge/Somerville/Medford Massachusetts	Yr of Base Year Dollars	2005
Project ID	Alternative 1A - Green Line to West Medford		
Phase	AA	Yr of Revenue Ops	TBD
Contracting Method		Forecast Year	2025
Number of Route Miles	4.45	Number of Stations	8

	Quantity	Base Year Dollars Total (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**4.45**	**93,371**	**$ 20,982**	**66%**	**24%**	**0**
10.01 Guideway: At-grade exclusive right-of-way	3.08	25,473	$ 8,270			
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)						
10.03 Guideway: At-grade in mixed traffic						
10.04 Guideway: Aerial structure	0.31	23,856	$ 76,955			
10.05 Guideway: Built-up fill	0.19	2,689	$ 14,153			
10.06 Guideway: Underground cut & cover	0.07	16,210	$ 231,571			
10.07 Guideway: Underground tunnel						
10.08 Guideway: Retained cut or fill	0.80	12,815	$ 16,019			
10.09 Track: Direct fixation						
10.10 Track: Embedded						
10.11 Track: Ballasted		9,868				
10.12 Track: Special (switches, turnouts)		2,460				
10.13 Track: Vibration and noise dampening						
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**7**	**3,745**	**$ 535**	**3%**	**1%**	**0**
20.01 At-grade station, stop, shelter, mall, terminal, platform	7	3,745	$ 535			
20.02 Aerial station, stop, shelter, mall, terminal, platform						
20.03 Underground station, stop, shelter, mall, terminal, platform						
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.						
20.05 Joint development						
20.06 Automobile parking multi-story structure						
20.07 Elevators, escalators						
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	4.45	**6,150**	**$ 1,382**	**4%**	**2%**	**0**
30.01 Administration Building: Office, sales, storage, revenue counting						
30.02 Light Maintenance Facility		3,150				
30.03 Heavy Maintenance Facility						
30.04 Storage or Maintenance of Way Building						
30.05 Yard and Yard Track		3,000				
40 SITEWORK & SPECIAL CONDITIONS	4.45	**1,762**	**$ 396**	**1%**	**0%**	**0**
40.01 Demolition, Clearing, Earthwork		1,762				
40.02 Site Utilities, Utility Relocation						
40.03 Haz. mat'l, contam'd soil removal/mitigation, ground water treatments						
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks						
40.05 Site structures including retaining walls, sound walls						
40.06 Pedestrian / bike access and accommodation, landscaping						
40.07 Automobile, bus, van accessways including roads, parking lots						
40.08 Temporary Facilities and other indirect costs during construction						
50 SYSTEMS	4.45	**37,132**	**$ 8,344**	**26%**	**10%**	**0**
50.01 Train control and signals		26,668				
50.02 Traffic signals and crossing protection						
50.03 Traction power supply: substations		6,000				
50.04 Traction power distribution: catenary and third rail		4,464				
50.05 Communications						
50.06 Fare collection system and equipment						
50.07 Central Control						
Construction Subtotal (Sum Categories 10 - 50)	4.45	**142,160**	**$ 31,946**	**100%**	**36%**	**0**
60 ROW, LAND, EXISTING IMPROVEMENTS	4.45	**9,275**	**$ 2,084**		**2%**	**0**
60.01 Purchase or lease of real estate		9,275				
60.02 Relocation of existing households and businesses						
70 VEHICLES (number)	**38**	**106,400**	**$ 2,800**		**27%**	**0**
70.01 Light Rail	38	106,400	$ 2,800			
70.02 Heavy Rail						
70.03 Commuter Rail						
70.04 Bus						
70.05 Other						
70.06 Non-revenue vehicles						
70.07 Spare parts						
80 PROFESSIONAL SERVICES	4.45	**60,887**	**$ 13,682**		**16%**	**0**
80.01 Preliminary Engineering		7,475				
80.02 Final Design		13,890				
80.03 Project Management for Design and Construction		18,160				
80.04 Construction Administration & Management		21,362				
80.05 Insurance						
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.						
80.07 Surveys, Testing, Investigation, Inspection						
80.08 Agency Force Account Work						
90 UNALLOCATED CONTINGENCY		**71,278**			**18%**	**0**
Subtotal (Sum Categories 10 - 90)	4.45	**390,000**	**$ 87,640**		**100%**	**0**
100 FINANCE CHARGES		**0**			**0%**	**0**
Total Project Cost (Sum Categories 10 - 100)	4.45	**390,000**	**$ 87,640**		**100%**	**0**

YOE Construction Cost per Mile (X000)	$ -
YOE Total Project Cost per Mile (X000)	**$ -**
Base Year Soft Costs & Contingency/Construction (80 + 90) / (10 thru 50)	93%

Major Capital Project Costs - Main Worksheet (Rev. 1, Jan. 21, 2005)

Project	Beyond Lechmere	Today's Date	3/29/05
Location	Cambridge/Somerville/Medford Massachusetts	Yr of Base Year Dollars	2005
Project ID	Alternative 1C - Green Line to West Medford/Union Square		
Phase	AA	Yr of Revenue Ops	TBD
Contracting Method		Forecast Year	2025
Number of Route Miles	5	Number of Stations	8

	Quantity	Base Year Dollars Total (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**5.10**	**121,096**	**$ 23,744**	**69%**	**28%**	**0**
10.01 Guideway: At-grade exclusive right-of-way	3.73	30,826	$ 8,264			
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)						
10.03 Guideway: At-grade in mixed traffic						
10.04 Guideway: Aerial structure	0.43	33,177	$ 77,156			
10.05 Guideway: Built-up fill	0.30	4,259	$ 14,197			
10.06 Guideway: Underground cut & cover	0.07	18,704	$ 267,200			
10.07 Guideway: Underground tunnel						
10.08 Guideway: Retained cut or fill	0.57	15,191	$ 26,651			
10.09 Track: Direct fixation						
10.10 Track: Embedded						
10.11 Track: Ballasted		13,609				
10.12 Track: Special (switches, turnouts)		5,330				
10.13 Track: Vibration and noise dampening						
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**8**	**4,280**	**$ 535**	**2%**	**1%**	**0**
20.01 At-grade station, stop, shelter, mall, terminal, platform	8	4,280	$ 535			
20.02 Aerial station, stop, shelter, mall, terminal, platform						
20.03 Underground station, stop, shelter, mall, terminal, platform						
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.						
20.05 Joint development						
20.06 Automobile parking multi-story structure						
20.07 Elevators, escalators						
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	5.10	**6,150**	**$ 1,206**	**4%**	**1%**	**0**
30.01 Administration Building: Office, sales, storage, revenue counting						
30.02 Light Maintenance Facility		3,150				
30.03 Heavy Maintenance Facility						
30.04 Storage or Maintenance of Way Building						
30.05 Yard and Yard Track		3,000				
40 SITEWORK & SPECIAL CONDITIONS	5.10	**2,035**	**$ 399**	**1%**	**0%**	**0**
40.01 Demolition, Clearing, Earthwork		2,035				
40.02 Site Utilities, Utility Relocation						
40.03 Haz. mat'l, contam'd soil removal/mitigation, ground water treatments						
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks						
40.05 Site structures including retaining walls, sound walls						
40.06 Pedestrian / bike access and accommodation, landscaping						
40.07 Automobile, bus, van accessways including roads, parking lots						
40.08 Temporary Facilities and other indirect costs during construction						
50 SYSTEMS	5.10	**41,239**	**$ 8,086**	**24%**	**9%**	**0**
50.01 Train control and signals		30,083				
50.02 Traffic signals and crossing protection						
50.03 Traction power supply: substations		6,000				
50.04 Traction power distribution: catenary and third rail		5,156				
50.05 Communications						
50.06 Fare collection system and equipment						
50.07 Central Control						
Construction Subtotal (Sum Categories 10 - 50)	5.10	**174,800**	**$ 34,275**	**100%**	**40%**	**0**
60 ROW, LAND, EXISTING IMPROVEMENTS	5.10	**13,200**	**$ 2,588**		**3%**	**0**
60.01 Purchase or lease of real estate		13,200				
60.02 Relocation of existing households and businesses						
70 VEHICLES (number)	**32**	**89,600**	**$ 2,800**		**20%**	**0**
70.01 Light Rail	32	89,600	$ 2,800			
70.02 Heavy Rail						
70.03 Commuter Rail						
70.04 Bus						
70.05 Other						
70.06 Non-revenue vehicles						
70.07 Spare parts						
80 PROFESSIONAL SERVICES	5.10	**74,410**	**$ 14,590**		**17%**	**0**
80.01 Preliminary Engineering		9,140				
80.02 Final Design		16,970				
80.03 Project Management for Design and Construction		22,190				
80.04 Construction Administration & Management		26,110				
80.05 Insurance						
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.						
80.07 Surveys, Testing, Investigation, Inspection						
80.08 Agency Force Account Work						
90 UNALLOCATED CONTINGENCY		**85,990**			**20%**	**0**
Subtotal (Sum Categories 10 - 90)	5.10	**438,000**	**$ 85,882**		**100%**	**0**
100 FINANCE CHARGES		**0**			**0%**	**0**
Total Project Cost (Sum Categories 10 - 100)	5.10	**438,000**	**$ 85,882**		**100%**	**0**
YOE Construction Cost per Mile (X000)			$ -			
YOE Total Project Cost per Mile (X000)			**$ -**			
Base Year Soft Costs & Contingency/Construction (80 + 90) / (10 thru 50)			92%			

Major Capital Project Costs - Main Worksheet (Rev. 1, Jan. 21, 2005)

Project	Beyond Lechmere	Today's Date	3/29/05
Location	Cambridge/Somerville/Medford Massachusetts	Yr of Base Year Dollars	2005
Project ID	Alternative 2B - BRT to West Medford _ Green Line to Union Sq.		
Phase	AA	Yr of Revenue Ops	TBD
Contracting Method		Forecast Year	2025
Number of Route Miles	5.1	Number of Stations	8

	Quantity	Base Year Dollars Total (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**5.10**	**111,778**	**$ 21,917**	**80%**	**33%**	**0**
10.01 Guideway: At-grade exclusive right-of-way	3.73	39,363	$ 10,553			
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)						
10.03 Guideway: At-grade in mixed traffic						
10.04 Guideway: Aerial structure	0.43	25,895	$ 60,221			
10.05 Guideway: Built-up fill	0.30	5,604	$ 18,680			
10.06 Guideway: Underground cut & cover	0.07	18,704	$ 267,200			
10.07 Guideway: Underground tunnel						
10.08 Guideway: Retained cut or fill	0.57	15,191	$ 26,651			
10.09 Track: Direct fixation						
10.10 Track: Embedded						
10.11 Track: Ballasted		3,741				
10.12 Track: Special (switches, turnouts)		3,280				
10.13 Track: Vibration and noise dampening						
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**8**	**7,655**	**$ 957**	**5%**	**2%**	**0**
20.01 At-grade station, stop, shelter, mall, terminal, platform	8	7,655	$ 957			
20.02 Aerial station, stop, shelter, mall, terminal, platform						
20.03 Underground station, stop, shelter, mall, terminal, platform						
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.						
20.05 Joint development						
20.06 Automobile parking multi-story structure						
20.07 Elevators, escalators						
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	5.10	**10,000**	**$ 1,961**	**7%**	**3%**	**0**
30.01 Administration Building: Office, sales, storage, revenue counting						
30.02 Light Maintenance Facility		7,000				
30.03 Heavy Maintenance Facility						
30.04 Storage or Maintenance of Way Building						
30.05 Yard and Yard Track		3,000				
40 SITEWORK & SPECIAL CONDITIONS	5.10	**2,035**	**$ 399**	**1%**	**1%**	**0**
40.01 Demolition, Clearing, Earthwork		2,035				
40.02 Site Utilities, Utility Relocation						
40.03 Haz. mat'l, contam'd soil removal/mitigation, ground water treatments						
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks						
40.05 Site structures including retaining walls, sound walls						
40.06 Pedestrian / bike access and accommodation, landscaping						
40.07 Automobile, bus, van accessways including roads, parking lots						
40.08 Temporary Facilities and other indirect costs during construction						
50 SYSTEMS	5.10	**7,960**	**$ 1,561**	**6%**	**2%**	**0**
50.01 Train control and signals		4,135				
50.02 Traffic signals and crossing protection		1,050				
50.03 Traction power supply: substations		2,000				
50.04 Traction power distribution: catenary and third rail		775				
50.05 Communications						
50.06 Fare collection system and equipment						
50.07 Central Control						
Construction Subtotal (Sum Categories 10 - 50)	5.10	**139,428**	**$ 27,339**	**100%**	**41%**	**0**
60 ROW, LAND, EXISTING IMPROVEMENTS	5.10	**9,150**	**$ 1,794**		**3%**	**0**
60.01 Purchase or lease of real estate		9,150				
60.02 Relocation of existing households and businesses						
70 VEHICLES (number)	**35**	**64,680**	**$ 1,848**		**19%**	**0**
70.01 Light Rail	21	58,800	$ 2,800			
70.02 Heavy Rail						
70.03 Commuter Rail						
70.04 Bus	14	5,880	$ 420			
70.05 Other						
70.06 Non-revenue vehicles						
70.07 Spare parts						
80 PROFESSIONAL SERVICES	5.10	**59,050**	**$ 11,578**		**17%**	**0**
80.01 Preliminary Engineering		7250				
80.02 Final Design		13,500				
80.03 Project Management for Design and Construction		17,600				
80.04 Construction Administration & Management		20,700				
80.05 Insurance						
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.						
80.07 Surveys, Testing, Investigation, Inspection						
80.08 Agency Force Account Work						
90 UNALLOCATED CONTINGENCY		**67,692**			**20%**	**0**
Subtotal (Sum Categories 10 - 90)	5.10	**340,000**	**$ 66,667**		**100%**	**0**
100 FINANCE CHARGES		**0**			**0%**	**0**
Total Project Cost (Sum Categories 10 - 100)	5.10	**340,000**	**$ 66,667**		**100%**	**0**
YOE Construction Cost per Mile (X000)			$ -			
YOE Total Project Cost per Mile (X000)			**$ -**			
Base Year Soft Costs & Contingency/Construction (80 + 90) / (10 thru 50)			91%			

Major Capital Project Costs - Main Worksheet (Rev. 1, Jan. 21, 2005)

Project	**Beyond Lechmere**	Today's Date	**3/29/05**
Location	Cambridge/Somerville/Medford Massachusetts	Yr of Base Year Dollars	2005
Project ID	Alternative 3A - Commuter Rail to West Medford		
Phase	AA	Yr of Revenue Ops	TBD
Contracting Method		Forecast Year	2025
Number of Route Miles		Number of Stations	3

	Quantity	Base Year Dollars Total (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**2.12**	**26,272**	**$ 12,392**	**61%**	**15%**	**0**
10.01 Guideway: At-grade exclusive right-of-way	2.01	2,800	$ 1,393			
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)						
10.03 Guideway: At-grade in mixed traffic						
10.04 Guideway: Aerial structure	0.02	1,165	$ 58,250			
10.05 Guideway: Built-up fill		0				
10.06 Guideway: Underground cut & cover	0.02	3,325	$ 166,250			
10.07 Guideway: Underground tunnel						
10.08 Guideway: Retained cut or fill	0.07	11,588	$ 165,543			
10.09 Track: Direct fixation						
10.10 Track: Embedded						
10.11 Track: Ballasted		4,524				
10.12 Track: Special (switches, turnouts)		2,870				
10.13 Track: Vibration and noise dampening						
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**2**	**8,000**	**$ 4,000**	**19%**	**5%**	**0**
20.01 At-grade station, stop, shelter, mall, terminal, platform	2	8,000	$ 4,000			
20.02 Aerial station, stop, shelter, mall, terminal, platform						
20.03 Underground station, stop, shelter, mall, terminal, platform						
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.						
20.05 Joint development						
20.06 Automobile parking multi-story structure						
20.07 Elevators, escalators						
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	2.12	**0**	**$ -**	**0%**	**0%**	**0**
30.01 Administration Building: Office, sales, storage, revenue counting						
30.02 Light Maintenance Facility						
30.03 Heavy Maintenance Facility						
30.04 Storage or Maintenance of Way Building						
30.05 Yard and Yard Track						
40 SITEWORK & SPECIAL CONDITIONS	2.12	**808**	**$ 381**	**2%**	**0%**	**0**
40.01 Demolition, Clearing, Earthwork		808				
40.02 Site Utilities, Utility Relocation						
40.03 Haz. mat'l, contam'd soil removal/mitigation, ground water treatments						
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks						
40.05 Site structures including retaining walls, sound walls						
40.06 Pedestrian / bike access and accommodation, landscaping						
40.07 Automobile, bus, van accessways including roads, parking lots						
40.08 Temporary Facilities and other indirect costs during construction						
50 SYSTEMS	2.12	**8,070**	**$ 3,807**	**19%**	**5%**	**0**
50.01 Train control and signals		8,070				
50.02 Traffic signals and crossing protection						
50.03 Traction power supply: substations						
50.04 Traction power distribution: catenary and third rail						
50.05 Communications						
50.06 Fare collection system and equipment						
50.07 Central Control						
Construction Subtotal (Sum Categories 10 - 50)	2.12	**43,150**	**$ 20,354**	**100%**	**25%**	**0**
60 ROW, LAND, EXISTING IMPROVEMENTS	2.12	**2,000**	**$ 943**		**1%**	**0**
60.01 Purchase or lease of real estate		2,000				
60.02 Relocation of existing households and businesses						
70 VEHICLES (number)	**34**	**89,000**	**$ 2,618**		**52%**	**0**
70.01 Light Rail						
70.02 Heavy Rail						
70.03 Commuter Rail	34	89,000	$ 2,618			
70.04 Bus						
70.05 Other						
70.06 Non-revenue vehicles						
70.07 Spare parts						
80 PROFESSIONAL SERVICES	2.12	**17,750**	**$ 8,373**		**10%**	**0**
80.01 Preliminary Engineering		2,200				
80.02 Final Design		4,050				
80.03 Project Management for Design and Construction		5,300				
80.04 Construction Administration & Management		6,200				
80.05 Insurance						
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.						
80.07 Surveys, Testing, Investigation, Inspection						
80.08 Agency Force Account Work						
90 UNALLOCATED CONTINGENCY		**19,100**			**11%**	**0**
Subtotal (Sum Categories 10 - 90)	2.12	**171,000**	**$ 80,660**		**100%**	**0**
100 FINANCE CHARGES		**0**			**0%**	**0**
Total Project Cost (Sum Categories 10 - 100)	2.12	**171,000**	**$ 80,660**		**100%**	**0**
YOE Construction Cost per Mile (X000)			$ -			
YOE Total Project Cost per Mile (X000)			**$ -**			
Base Year Soft Costs & Contingency/Construction (80 + 90) / (10 thru 50)			85%			

Major Capital Project Costs - Main Worksheet (Rev. 1, Jan. 21, 2005)

Project	**Beyond Lechmere**	Today's Date	**3/29/05**
Location	Cambridge/Somerville/Medford Massachusetts	Yr of Base Year Dollars	2005
Project ID	Alternative 3B - Commuter Rail to Anderson Transportation Center		
Phase	AA	Yr of Revenue Ops	TBD
Contracting Method		Forecast Year	2025
Number of Route Miles		Number of Stations	3

	Quantity	Base Year Dollars Total (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**11.30**	**83,945**	**$ 7,429**	**74%**	**24%**	**0**
10.01 Guideway: At-grade exclusive right-of-way	8.67	13,383	$ 1,544			
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)						
10.03 Guideway: At-grade in mixed traffic						
10.04 Guideway: Aerial structure	0.12	15,117	$ 125,975			
10.05 Guideway: Built-up fill	0.19	2,690	$ 14,158			
10.06 Guideway: Underground cut & cover	0.05	12,050	$ 241,000			
10.07 Guideway: Underground tunnel						
10.08 Guideway: Retained cut or fill	2.27	17,308	$ 7,625			
10.09 Track: Direct fixation						
10.10 Track: Embedded						
10.11 Track: Ballasted		19,707				
10.12 Track: Special (switches, turnouts)		3,690				
10.13 Track: Vibration and noise dampening						
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**3**	**12,000**	**$ 4,000**	**11%**	**3%**	**0**
20.01 At-grade station, stop, shelter, mall, terminal, platform	3	12,000	$ 4,000			
20.02 Aerial station, stop, shelter, mall, terminal, platform						
20.03 Underground station, stop, shelter, mall, terminal, platform						
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.						
20.05 Joint development						
20.06 Automobile parking multi-story structure						
20.07 Elevators, escalators						
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	11.30	**0**	**$ -**	**0%**	**0%**	**0**
30.01 Administration Building: Office, sales, storage, revenue counting						
30.02 Light Maintenance Facility						
30.03 Heavy Maintenance Facility						
30.04 Storage or Maintenance of Way Building						
30.05 Yard and Yard Track						
40 SITEWORK & SPECIAL CONDITIONS	11.30	**3,565**	**$ 315**	**3%**	**1%**	**0**
40.01 Demolition, Clearing, Earthwork		3,565				
40.02 Site Utilities, Utility Relocation						
40.03 Haz. mat'l, contam'd soil removal/mitigation, ground water treatments						
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks						
40.05 Site structures including retaining walls, sound walls						
40.06 Pedestrian / bike access and accommodation, landscaping						
40.07 Automobile, bus, van accessways including roads, parking lots						
40.08 Temporary Facilities and other indirect costs during construction						
50 SYSTEMS	11.30	**13,775**	**$ 1,219**	**12%**	**4%**	**0**
50.01 Train control and signals		13,375				
50.02 Traffic signals and crossing protection		400				
50.03 Traction power supply: substations						
50.04 Traction power distribution: catenary and third rail						
50.05 Communications						
50.06 Fare collection system and equipment						
50.07 Central Control						
Construction Subtotal (Sum Categories 10 - 50)	11.30	**113,285**	**$ 10,025**	**100%**	**33%**	**0**
60 ROW, LAND, EXISTING IMPROVEMENTS	11.30	**5,400**	**$ 478**		**2%**	**0**
60.01 Purchase or lease of real estate		5,400				
60.02 Relocation of existing households and businesses						
70 VEHICLES (number)	**47**	**123,100**	**$ 2,619**		**35%**	**0**
70.01 Light Rail						
70.02 Heavy Rail						
70.03 Commuter Rail	47	123,100	$ 2,619			
70.04 Bus						
70.05 Other						
70.06 Non-revenue vehicles						
70.07 Spare parts						
80 PROFESSIONAL SERVICES	11.30	**48,450**	**$ 4,288**		**14%**	**0**
80.01 Preliminary Engineering		5950				
80.02 Final Design		11,050				
80.03 Project Management for Design and Construction		14,450				
80.04 Construction Administration & Management		17,000				
80.05 Insurance						
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.						
80.07 Surveys, Testing, Investigation, Inspection						
80.08 Agency Force Account Work						
90 UNALLOCATED CONTINGENCY		**56,765**			**16%**	**0**
Subtotal (Sum Categories 10 - 90)	11.30	**347,000**	**$ 30,708**		**100%**	**0**
100 FINANCE CHARGES		**0**			**0%**	**0**
Total Project Cost (Sum Categories 10 - 100)	11.30	**347,000**	**$ 30,708**		**100%**	**0**
YOE Construction Cost per Mile (X000)			$ -			
YOE Total Project Cost per Mile (X000)			**$ -**			
Base Year Soft Costs & Contingency/Construction (80 + 90) / (10 thru 50)			93%			

Major Capital Project Costs - Main Worksheet (Rev. 1, Jan. 21, 2005)

Project	**Beyond Lechmere**	Today's Date	**3/29/05**
Location	Cambridge/Somerville/Medford Massachusetts	Yr of Base Year Dollars	2005
Project ID	Alternative 4 - Transportation System Management Alternative		
Phase	AA	Yr of Revenue Ops	TBD
Contracting Method		Forecast Year	2025
Number of Route Miles	9	Number of Stations	0

	Quantity	Base Year Dollars Total (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**0.00**	**0**		**#DIV/0!**	**0%**	**0**
10.01 Guideway: At-grade exclusive right-of-way						
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)						
10.03 Guideway: At-grade in mixed traffic						
10.04 Guideway: Aerial structure						
10.05 Guideway: Built-up fill						
10.06 Guideway: Underground cut & cover						
10.07 Guideway: Underground tunnel						
10.08 Guideway: Retained cut or fill						
10.09 Track: Direct fixation						
10.10 Track: Embedded						
10.11 Track: Ballasted						
10.12 Track: Special (switches, turnouts)						
10.13 Track: Vibration and noise dampening						
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**0**	**0**		**#DIV/0!**	**0%**	**0**
20.01 At-grade station, stop, shelter, mall, terminal, platform						
20.02 Aerial station, stop, shelter, mall, terminal, platform						
20.03 Underground station, stop, shelter, mall, terminal, platform						
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.						
20.05 Joint development						
20.06 Automobile parking multi-story structure						
20.07 Elevators, escalators						
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	0.00	**0**		**#DIV/0!**	**0%**	**0**
30.01 Administration Building: Office, sales, storage, revenue counting						
30.02 Light Maintenance Facility						
30.03 Heavy Maintenance Facility						
30.04 Storage or Maintenance of Way Building						
30.05 Yard and Yard Track						
40 SITEWORK & SPECIAL CONDITIONS	0.00	**0**		**#DIV/0!**	**0%**	**0**
40.01 Demolition, Clearing, Earthwork						
40.02 Site Utilities, Utility Relocation						
40.03 Haz. mat'l, contam'd soil removal/mitigation, ground water treatments						
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks						
40.05 Site structures including retaining walls, sound walls						
40.06 Pedestrian / bike access and accommodation, landscaping						
40.07 Automobile, bus, van accessways including roads, parking lots						
40.08 Temporary Facilities and other indirect costs during construction						
50 SYSTEMS	0.00	**0**		**#DIV/0!**	**0%**	**0**
50.01 Train control and signals						
50.02 Traffic signals and crossing protection						
50.03 Traction power supply: substations						
50.04 Traction power distribution: catenary and third rail						
50.05 Communications						
50.06 Fare collection system and equipment						
50.07 Central Control						
Construction Subtotal (Sum Categories 10 - 50)	0.00	**0**		**#DIV/0!**	**0%**	**0**
60 ROW, LAND, EXISTING IMPROVEMENTS	0.00	**0**			**0%**	**0**
60.01 Purchase or lease of real estate						
60.02 Relocation of existing households and businesses						
70 VEHICLES (number)	**12**	**4,600**	**$ 383**		**100%**	**0**
70.01 Light Rail						
70.02 Heavy Rail						
70.03 Commuter Rail						
70.04 Bus	12	4,600	$ 383			
70.05 Other						
70.06 Non-revenue vehicles						
70.07 Spare parts						
80 PROFESSIONAL SERVICES	0.00	**0**			**0%**	**0**
80.01 Preliminary Engineering						
80.02 Final Design						
80.03 Project Management for Design and Construction						
80.04 Construction Administration & Management						
80.05 Insurance						
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.						
80.07 Surveys, Testing, Investigation, Inspection						
80.08 Agency Force Account Work						
90 UNALLOCATED CONTINGENCY					**0%**	**0**
Subtotal (Sum Categories 10 - 90)	0.00	**4,600**			**100%**	**0**
100 FINANCE CHARGES		**0**			**0%**	**0**
Total Project Cost (Sum Categories 10 - 100)	0.00	**4,600**			**100%**	**0**

YOE Construction Cost per Mile (X000) #DIV/0!

YOE Total Project Cost per Mile (X000) #DIV/0!

Base Year Soft Costs & Contingency/Construction (80 + 90) / (10 thru 50) #DIV/0!

Appendix D

Conceptual Operations & Maintenance Cost Estimate Detail

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BEYOND LECHMERE PROJECT

Operating and Maintenance
Cost Estimates

	Alternative 1A			Alternative 1C			Alternative 2B*		
Variable	Incremental Unit Change	Unit Cost	Total Cost	Incremental Unit Change	Unit Cost	Total Cost	Incremental Unit Change	Unit Cost	Total Cost
Stations - Green Line (Surface)	7	$ 73,763	$ 516,341	8	$ 73,763	$ 590,104	1	$ 73,763	$ 73,763
Stations - BRT							7	$ 73,763	$ 516,341
Peak Rail - Green Line	13	$ 44,270	$ 575,504	11	$ 44,270	$ 486,965	7	$ 44,270	$ 309,887
Peak Bus									
Peak BRT Bus							12	68,038	$ 816,457
Rev Veh Hrs - Green Line	129,250	$ 41	$ 5,287,931	101,043	41	$ 4,133,914	70,315	$ 40.9124	$ 2,876,757
Elec Rte Mile - Green Line	4.45	125,286	$ 557,522	5.1	125,286	$ 638,958	1.62	$ 125,286	$ 202,963
Elec Rte Mile - BRT							-	132,278	$ -
Rev Veh Hrs - Bus									
Rev Veh Hrs - BRT							51,966	$ 23.3747	$ 1,214,692
Rev Veh Hrs - Commuter Rail									
Rev Veh Miles - Diesel Bus									
Rev Veh Miles - BRT							715,204	$ 4.5185	$ 3,231,617
Rev Veh Miles - Green Line	1,788,000	1	$ 1,694,149	1,780,000	$ 0.9475	$ 1,686,569	650,916	$ 0.9475	$ 616,750
Total Directly Operated Ridership	4,163,040	$ 0.0510	$ 212,355	2,957,640	$ 0.0510	$ 150,868	3,113,460	$ 0.0510	$ 158,817
Number of Maintenance Facilities	1	1,061,157	$ 1,061,157	1	1,061,157	$ 1,061,157	1	1,061,157	$ 1,061,157
Total O&M Cost			**$ 9,904,959**			**$ 8,748,535**			**$ 11,079,200**
Fare Revenue			**$ 4,878,695**			**$ 3,416,280**			**$ 4,013,923**
Total	**Incremental Cost**		**$ 5,000,000**	**Incremental Cost**		**$ 5,300,000**	**Incremental Cost**		**$ 7,100,000**
*Model amended so that O&M Cost for BRT Station equals Green Line Surface Station not underground SilverLine type station									

BEYOND LECHMERE PROJECT

Operating and Maintenance
Cost Estimates

	Alternative 3A			Alternative 3B			Alternative 4		
Variable	Incremental Unit Change	Unit Cost	Total Cost	Incremental Unit Change	Unit Cost	Total Cost	Incremental Unit Change	Unit Cost	Total Cost
Stations - Green Line (Surface)									
Stations - BRT									
Peak Rail - Green Line									
Peak Bus							10	$37,180	$ 371,797
Peak BRT Bus									
Rev Veh Hrs - Green Line									
Elec Rte Mile - Green Line									
Elec Rte Mile - BRT									
Rev Veh Hrs - Bus							27,612	$36.17	$ 998,728
Rev Veh Hrs - BRT									
Rev Veh Hrs - Commuter Rail	12,152	$300.69	$ 3,653,928	18,032	$300.69	$ 5,421,958			
Rev Veh Miles - Diesel Bus							361,620	$1.07	$ 386,506
Rev Veh Miles - BRT									
Rev Veh Miles - Green Line									
Total Directly Operated Ridership							464,520	$ 0.0510	$ 23,695
Number of Maintenance Facilities									
Total O&M Cost			**$ 3,653,928**			**$ 5,421,958**			**$ 1,780,726**
Fare Revenue			**$ 589,205**			**$ 1,227,803**			**$ 190,777**
Total	**Incremental Cost**		**$ 3,100,000**	**Incremental Cost**		**$ 4,200,000**	**Incremental Cost**		**$ 1,600,000**
*Model amended so that O&M Cost for B									

Appendix E

CTPS Memo on Beyond Lechmere Modeling Methodology

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CTPS CENTRAL TRANSPORTATION PLANNING STAFF
Staff to the Boston Metropolitan Planning Organization

DRAFT MEMORANDUM

To: **Joe Cosgrove, MBTA** **April 29, 2005**

From: **Scott Peterson, CTPS**

Re: **Beyond Lechmere Modeling Methodology**

I. INTRODUCTION

The MBTA is studying alternatives for transit improvements in the Medford/Somerville corridor beyond Lechmere Station. Among the improvement options to be analyzed are variant routings for extension of the Green Line.

The Green Line of four light rail branches that converge in a central subway that includes the oldest section of subway in North America. Currently, the services on the D and E branches terminate at Lechmere Station. The proposal to extend the current service beyond Lechmere to Medford Hillside or other points has been in existence for many years. It has been studied briefly in the past two Programs for Mass Transportation studies and now is a SIP, CA/T and ACO legal commitment.

The MBTA is working on a Major Investment Study report for this project and CTPS has been asked by the MBTA to provide ridership, revenue, user benefit, and air quality forecasts in support of the alternative analysis being conducted for this study.

The alternative analysis examined seven scenarios for the year 2025:

1. Scenario 1 is a No-build that pivots of the 2004-2025 Regional Transportation Plan Preferred Plan, but is doesn't include the Green Line Extension to W. Medford.
2. Scenario 2 is a Transportation Systems Management (TSM) option that improves headways on four existing buses in the no-build scenario, namely (Rte 80, 87, 88, and 101), and adds 1 new circulator service between Boson Ave and Davis Sq. This scenario is also referred to as alternative. 4).
3. Scenario 3 extends the Green Line D and E branch to W. Medford. This scenario is also referred to as alternative 1A.
4. Scenario 4 extends the Green Line E branch to Union Sq. and extends the D branch to W. Medford. This scenario is also referred to as alternative 1C.
5. Scenario 5 extends the Green Line D and E branch to Union Sq. and would provide a bus-rapid-transit (BRT) option between W. Medford and Lechmere. This scenario is also referred to as alternative 2B.

6. Scenario 6 provides a commuter rail shuttle along a third track of the Lowell Line with a 15-minute headway between W. Medford and North Station. This scenario is also referred to as alternative 3A.
7. Scenario 7 provides a commuter rail shuttle along a third track of the Lowell Line between Anderson Regional Transportation Center with a 15-minute headway between Woburn and N. Station. This scenario is also referred to as alternative 3B.

The differences between the no-build and the build scenario results will form the basis for analyzing the ridership and air quality impacts of each alternative. This memorandum summarizes the methodology used in support of the Beyond Lechmere alternative analysis and concludes with an overview of results.

II. TRAVEL DEMAND MODEL

General Description of the Model

The travel model set is based on procedures that have evolved over many years at the Central Transportation Planning Staff (CTPS). The model set is based on the traditional four-step urban transportation planning process of trip generation, trip distribution, mode choice, and trip assignment and is implemented in the EMME/2 software package. This process is employed to estimate daily transit ridership and highway traffic volumes, primarily on the basis of forecasts of study area demography, land use assumptions, and projected highway and transit improvements. The model set simulates travel on the entire eastern Massachusetts transit and highway system.

The Four Steps

In the first step, the total number of trips generated by residents of the CTPS Modeling Area (the 101 MAPC cities and towns that make up the Boston MPO together with 63 communities outside of the Boston MPO) is calculated using demographic and socioeconomic data. Similarly, the number of trips attracted to different types of land use such as employment centers, schools, hospitals, shopping centers etc., is estimated using land use data and trip generation rates obtained from travel surveys. This information is produced at disaggregated geographic areas known as traffic analysis zones (TAZ). All calculations are performed at the TAZ level.

In the second step, the model determines how the trips generated in each TAZ are distributed throughout the region. Trips are distributed based on transit and highway travel times between TAZs and the relative attractiveness of each TAZ which is influenced by the number of jobs available, size of schools, hospitals, shopping centers etc.

Once the total number of trips between TAZs is determined, the mode choice step of the model (step three) allocates the total trips among the available modes of travel. In our case, the available modes of travel are walk, auto (SOV and carpools) and transit (walking to transit and driving to transit). To determine the proportions of each mode, the model takes into account the travel times, number of transfers required, parking availability and costs associated with these options. Other variables such as the auto ownership and household size are also included in the model.

After estimating the number of transit and auto trips for all possible TAZ combinations, the model assigns them to their respective mode of transportation (this is the fourth and final step). Various reports showing the transit ridership on different transit modes (including estimates of passenger boardings on all the existing and proposed transit lines) and traffic volumes on the highway network are produced according to our needs. A schematic representation of the modeling process is shown in Figure 1.

Model Features

The model set uses the best component models, networks and input data available to CTPS at this time. Some of the features of the model set include:

- The model set incorporates motorized and non-motorized trips.
- The model is set up to simulate passenger and highway travel during four time periods of a typical weekday.
- The trip generation, trip distribution and mode choice portions of the model set are well calibrated.
- The model set recognizes the parking lot capacity constraints when assigning park and ride trips but isn't constrained by them.
- The park and ride trips can be reassigned to the highway network for a more realistic highway assignment.
- EMME/2 software used in implementing the model is capable of performing simultaneous multi-class and multi-path and transit highway assignment that is superior to the traditional all-or-nothing assignment.
- The procedure that estimates air quality benefits is sophisticated and well integrated within the main model.

Description of Model Parameters

Modeled Area: The modeled area encompasses 164 cities and towns in Eastern Massachusetts, which includes 101 MAPC region cities and towns, and 63 Communities outside of Boston MPO, as shown in Figure 2. The figure also shows the boundaries of five concentric rings into which the modeled area is divided for model estimation and calibration purposes. These rings will be referred to in subsequent discussions.

Figure 1: The Four Step Demand Modeling Processes

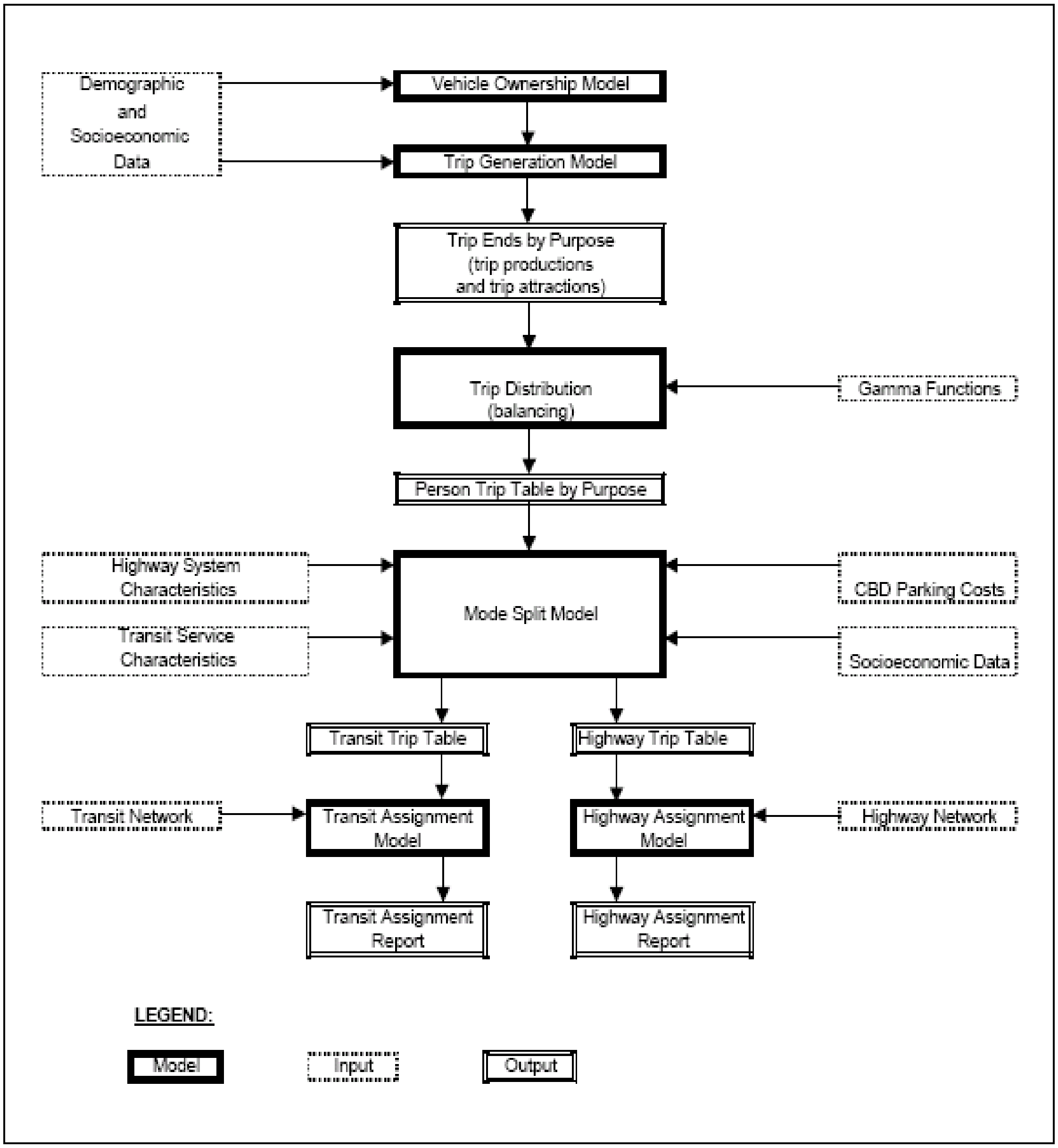
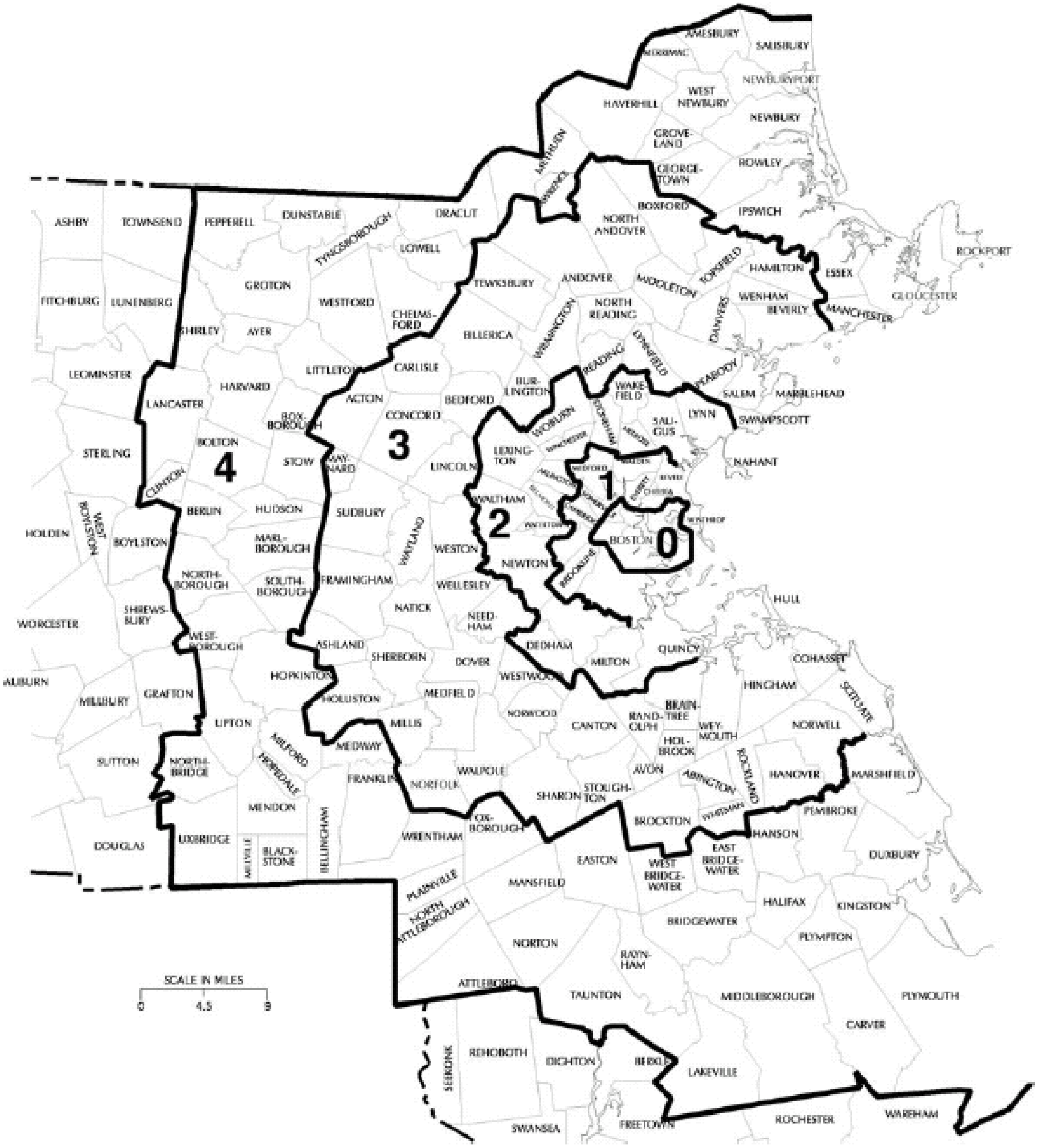

Demographic and Socioeconomic Data
Vehicle Ownership Model
Trip Generation Model
Trip Ends by Purpose (trip productions and trip attractions)
Trip Distribution (balancing)
Gamma Functions
Person Trip Table by Purpose
Highway System Characteristics
Transit Service Characteristics
Mode Split Model
CBD Parking Costs
Socioeconomic Data
Transit Trip Table
Highway Trip Table
Transit Network
Transit Assignment Model
Highway Assignment Model
Highway Network
Transit Assignment Report
Highway Assignment Report
LEGEND:
Model
Input
Output

FIGURE 2 CTPS Modeled Area and Ring Boundaries



Zone System: The modeled area is divided into 986 internal Traffic Analysis Zones (TAZs). There are 97 external stations around the periphery of the modeled area that allow for travel between the modeled area and adjacent areas of Massachusetts, New Hampshire and Rhode Island.

Model Inputs: The model inputs include: Population/households, employment, transit level of service, transit fares, highway level of service, highway tolls, and automobile operating costs including parking. This section lists the major data items underlying the model set.

1990 and 2000 U.S. Census: Various files were used in model estimation and calibration processes.

Site-level Employment Database: Employment estimates for 1991 were taken from state-provided sources and a commercial vendor's database purchased by CTPS, and combined into a single, unified regional employment database.

Household Travel Survey: In 1991, CTPS conducted a household travel survey. Then survey took the form of an activity-based travel diary that was filled out for one weekday. Approximately 4,000 households, generating some 39,000-weekday trips were represented in the final database. The data were used to estimate new trip generation, auto ownership, trip distribution and mode choice models.

Transportation Networks: There are two types of networks; transit and highway. Both are integrated in EMME/2. The highway network is comprised of express highways, principal & minor arterials and local roadways. The transit network is comprised of commuter rail lines, rapid transit lines and bus lines (MBTA + Private carriers). The model contains service frequency (i.e. how often trains and buses run), routing, travel time and fares for all lines.

External Cordon Survey: Also in 1991, a survey of automobile travelers bound for the modeled area from adjacent areas was performed. Survey results were used in trip generation and distribution to update estimates of external trips.

Ground Counts: Transit ridership and highway traffic volume data representing 2000 through 2004 conditions were amassed into a database and used to calibrate the travel sub-models.

Analysis Year: Base year is 2004 and the horizon year is 2025 for which the Land Use Scenario is based on Trends Extended.

Highway Network: The regional highway network contains in excess of 40,000 links and 15,000 nodes. It is fairly dense in the study area, although like any modeled network, it does not include some local and collector streets. Each link is coded with the appropriate free-flow speed, number of lanes and lane capacity. Functional class is coded, as are various geographic flags useful for summarizing emissions.

Transit Network: The transit network represents all MBTA bus and rail services in Eastern Massachusetts, as well as private express buses and Boston Harbor ferries. Most-likely travel paths are built through the network, then skimmed and the resulting impedances are input to the trip distribution and mode choice models. After mode choice, transit trip tables by time of day are assigned to the network travel paths.

Time of Day Considerations: In the current version of the travel model set, the mode choice and transit assignment are conducted for four time periods: AM peak period, Midday, PM peak period, and night-time. The trip generation model however, is based on daily trips. The trip distribution model considers two time periods, peak and off-peak periods.

The highway and transit networks are built separately for each time period. Table 1 shows the time intervals associated with each time period. The highway vehicle trips created by the mode choice model are converted from production/attraction format to an origin/destination format prior to network assignment. Transit person trips are also transformed from production/attraction format to origin/destination format, for each time period and assigned to the transit network.

The factors used in dividing the highway person trips into different time periods were obtained from the 1991 Household Travel Survey. The final trip tables created for each time period correspond to observed levels of congestion on the highway system. The results of the four assignments are summed to obtain daily (AWDT) results.

Table 1 – Time Periods for Trip Assignment

Time Period	Highway Vehicle Trips	Transit Person Trips
AM Peak Period	6:00 am - 9:00 am	6:00 am - 9:00 am
Midday	9:00 am - 3:00 pm	9:00 am - 3:00 pm
PM Peak Period	3:00 pm - 6:00 pm	3:00 pm - 6:00 pm
Early/Evening/Night	6:00 pm – 6:00 am	6:00 pm – 6:00 am

Population and Employment Forecasts

Households and employment by type are major inputs to the travel model process: they are the variables upon which trip generation is done. The Metropolitan Area Planning Council (MAPC) using what is called a “Targeted Growth” method developed the forecasts of households and employment for this region independently. In this method, growth is targeted to denser areas with available water and sewer infrastructure with a focus on development around transit stations.

Trip Generation Model

The first step in the CTPS Regional Travel Forecasting Model Set for Eastern Massachusetts is the trip generation model. This model uses socioeconomic characteristics of the region and basic information about regional transportation infrastructure, transportation services, and geography to predict the amounts of travel, which will be produced and attracted to the transportation analysis zones (TAZs) within the Eastern Massachusetts region.

The CTPS trip generation model is composed of the following nine parts and a description of each of these parts is presented thereafter:

- Base year inputs
- Future year inputs
- Estimation of base year input requirements for future years
- Estimation of detailed socioeconomic characteristics
- Estimation of vehicle ownership
- Estimation of trip productions and attractions
- Balancing of trip productions and attractions
- Elimination of Logan trip productions and attractions
- Preparation of files for other components of the regional model set

Base Year Inputs

The base year inputs required for the trip generation model include the following: total households, total population, group quarters population, households by household size, households by income quartile, households by workers per household, households by size, income, and workers per household, population by age, basic employment, retail trade employment, services employment, school employment (K-12 and college), resident workers, dorm population, labor participation rates, land area, Logan person trips, external person trips, attraction and production terminal times, and transit walk access factors . For the base year trip generation applications, data from the 2000 US Census of Population is used where available. Estimates for the year 2000 are generated for those variables that are still based upon 1990 US Census data through application of the forecast year procedures described below.

Future Year Inputs

The future year inputs required for the trip generation model include the following: total households, total population, group quarters population, population by age, basic employment, retail trade employment, services employment, labor participation rates, Logan growth factors, external growth factors, and transit walk access factors. These data are used to estimate the future year levels for the variables listed as base year input requirements following the procedures described below.

Estimation of Base Year Input Requirements for Future Years: Various procedures are used to prepare the trip generation model input data for future years. The variables that are estimated in these procedures include the following: households by household size, households by income quartile, resident workers, households by workers per household, school employment (K-12 and college), dorm population, Logan person trips, external person trips, and attraction and production terminal times.

Household Size: The change in TAZ average household size is implied in the base year inputs and future year forecasts (total population minus group quarters population divided by total households). The new distribution of households by household size is estimated by first distributing the future year households by size in the same proportions as in the base year. It is then assumed that all households capable of making the implied change (households of two or more for household size reductions; all households for household size increases) will have the same probability of changing in size by one. This probability of changing is set equal to the extent needed to match the forecast change in household size, and the resulting distribution of households by household size is used for the future scenario.

Household Income: The future year distribution of households by income quartile is estimated by assuming the proportional distribution of households by income quartile remains constant within each TAZ.

Resident Workers per Household: The change in the number of resident workers at the town level is obtained from combining base year and future year estimates of over-age-15 population and labor force participation by gender and age cohort. Dividing the base year and future year estimates of town-level resident workers by the base year and future year number of households in the town, respectively, produces estimates of the base year and future year average workers per household. All of the TAZs within each town are assumed to have the proportional change in workers per household implied by these base year and future year town-level estimates.

Household Workers: The future year TAZ number of households within each category of worker per household is estimated by using worker-per-household distribution curves developed by CTPS from the 1990 U.S. Census. These curves, summarized in Exhibit 4, indicate a default percentage distribution of households for the base year and future year TAZ estimates of average worker per household. The proportional changes in the default number of households within each category of worker per household implied by this comparison are applied to the actual base year TAZ distribution of households to obtain the distribution of households by workers per household to be used for the future scenario.

K-12 Employment: The level of employment in schools providing Kindergarten – 12th grade education is assumed to be proportional to the number of town residents of ages 5-19.

College Employment: The level of employment at all colleges within the region is assumed to be proportional to the number of regional residents of ages 20-24.

Dorm Population: The dorm population within a TAZ is assumed to be proportional to the total group quarters population within a TAZ.

Logan Person Trips: Base year Logan passenger trips are factored up by projected passenger growth rates to the future year. Base year Logan employee trips are factored up by projected Logan work force growth rates to the future year.

External Person Trips: Base year external person trips are factored up by population and employment growth rates implied in the forecasts of the neighboring regional planning agencies to the future year.

Attraction and Production Terminal Times: The attraction and production terminal times are estimated through the application of a model developed at CTPS. This model estimates terminal times as a function of household and employment density. Alternative estimates of the production and attraction terminal times for each TAZ are based on the household density ranges and employment density ranges. The larger of each pair of estimates are assigned to the TAZ. A few TAZs (locations of major generators such as airport or large colleges) were assigned terminal times in the base year different from the terminal time model estimates. In these cases, the model is used to estimate changes in the terminal times.

Estimation of Detailed Socioeconomic Characteristics

A three-way distribution of the households within each TAZ by household size, income, and workers is required in order to estimate the distribution of households by vehicle ownership levels. While this is available from the US Census at the regional level, such distributions at the TAZ level must be estimated through iterative proportional fitting techniques. Using the regional matrix as a seed, the cell values are adjusted through ten iterations to match row and column totals to the estimated ring-level totals to produce the three-way distribution of households for each geographical ring. Using these ring-level matrices as seeds, this process is then repeated for each TAZ within each ring.

Estimation of Vehicle Ownership

Household auto ownership is an input to trip generation and mode choice. It is forecast using a logit model developed with the 1991 Household Travel Survey and 1990 U.S. Census data. The model is integrated with the trip production procedures. The distribution of households by vehicle ownership estimated through the application of a set of models developed at CTPS. These models estimate the probability of a household owning a certain number of vehicles as a function of income, household size, workers per household, household density, employment density, household location, and transit walk access factors.

Estimation of Trip Productions and Attractions

The number of trip productions and trip attractions within a TAZ is estimated through the application of a set of models developed at CTPS. These models estimate the number of rip productions and attractions as a function of household size, workers per household, vehicles per household, income, household location, households, basic employment, retail employment, college employment, school employment, and service employment.

Balancing of Trip Productions and Attractions

Connecting a trip production with a trip attraction of the same trip purpose forms a trip. As a result, the number of productions and attractions for each trip purpose must be equal. In order to achieve this, the trip productions and attractions are balanced. The normal balancing procedure is to set the total number of regional attractions equal to the difference between the grand total of productions and the total number of external attractions. While that procedure was used to balance trip productions and attractions in 1995, the procedure required modifications for future year scenarios.

The large difference between regional employment and the number of resident workers and the large increase in external employment forecasted by the neighboring regional planning agencies and states produced home-based work trip volumes which seemed to be too high. In order to restrict trip volumes to plausible levels, the following changes were made in the balancing procedure:

- Regional home-based work trip productions are adjusted so that the increase from the base year total to the future year total is proportional to the forecast change in regional resident workers.
- Regional home-based work attractions were reduced by 3%, as was required to balance home-based work productions and attractions in 1990.
- External home-based work productions were set equal to the difference between the grand total of home-based work attractions and the regional home-based work productions.

Elimination of Logan Trip Productions and Attractions

While the total number of trip productions and attractions are equal, they include trips produced and attracted to Logan Airport. Since a separate model is used to estimate travel patterns to and from Logan Airport, Logan trips have to be purged from the trip matrices. The trips produced by or attracted to the Logan TAZs are thus eliminated, and Logan Airport passenger and employee survey data are used to identify the productions and attractions of other TAZs, which correspond to the Logan TAZ productions and attractions.

All of the Logan-related trips are eliminated from the original balanced estimates of trip productions and attractions, and files are produced which present estimates of the productions and attractions within each TAZ for home-based work, home-based personal business, home-based social and recreational, home-based school, home-based pick-up and drop-off, non-home-based work, and non-home-based other travel.

Preparation of Files for Other Components of Regional Model Set

In addition to trip productions and attractions, the results of the trip generation model also include several files used as inputs to other components of the regional model set.

Trip Distribution Model

The trip distribution model is the second step in the CTPS Regional Travel Forecasting Model Set. The trip distribution model links trip productions with trip attractions in the region to create matrixes of intra-regional and a portion of interregional travel.

Distribution of Internal-Internal Trips

The procedure developed relies on the implementation of a three-dimensional trip balancing strategy, as provided by the EMME/2 transportation planning software. Three dimensional trip balancing distributes production and attraction, which constitute the first and second dimensions respectively, subject to a third constraint on the distributed trips which is a combination of the scaled composite impedances and the total number of trips between districts. The 1991 transportation demand survey was used to define this third dimension constraint.

When applying the transportation demand model to generate trip demand forecasts, the object of a trip distribution model is the estimation of trip matrices based on future productions and attractions (P's & A's) given new transportation supply conditions, which translate into new composite impedance. A transportation demand survey exists only for the "base case", and therefore cannot be integrated in the procedure for evaluation of future scenarios. Thus, the object of the three-dimensional balancing procedure is broader than the generation of a trip matrix, which is the direct result of the balancing of productions and attractions. This step generates intermediate results useful for the calibration of a two-dimensional balancing for future year studies. The multipliers associated with the third dimension of this procedure were used to estimate "gamma" functions. Such functions of scaled composite impedances then allow for the creation of seed matrices of the trip distribution procedure (two-dimensional) to apply in scenario studies. These gamma functions translate the "reaction" of the three-dimensional procedure to the third dimension constraint and therefore, account for this constraint when applied to define a seed matrix.

The inputs of the procedure are:

- matrices of trip utilities, which are an output of the mode choice procedure;
- split factor matrices, which provide the total number of trips between district pairs for the peak and off-peak periods;
- trip-ends (production and attraction);
- household survey trip data.

Methodology

The procedure developed to distribute internal-internal trips relies on gamma functions derived from a three-dimensional balancing procedure and does not involve "friction factors" or "K factors." The gamma functions transform scaled composite impedances into seed values for the two-dimensional balancing. This procedure involved three steps:

- three-dimensional balancing, in which geographical information is combined with scaled composite impedance values to define the third constraint;
- estimation of gamma functions;
- two-dimensional balancing for future years productions and attractions, using the gamma functions to compute seed values.

A three-dimensional balancing model was calibrated first with the 1991 data (productions, attractions and household survey results) on 12 combinations of six trip purposes and of two time periods. The six purposes considered are: home-based work, "wk"; non home-based work, "nw"; non home-based other, "nbo"; school, "sc"; socio-recreational, "sr"; and shopping, "sh". The two periods considered are: peak, "pk"; and off-peak, "op." The "peak" context includes the AM and PM peak periods while the "off-peak" context regroups the mid-day and evening periods.

The mode choice model generates sets of 4 utility matrices, one for each of four periods considered in the mode choice model (AM, PM, MD and NT). The AM and PM utilities are combined to compute PK composite impedances and the MD and NT utilities are combined to compute OP composite impedances. Although 6 purposes are considered in this procedure, only 5 sets of utility matrices are used as input to the procedure, since the same utilities are applied to the shopping and socio-recreational purposes. There are 12 split factor matrices, corresponding to each purpose and period combination of the trip distribution procedure. These matrices provide the respective shares of AM and PM trips for the PK periods, and the shares of MD and NT trips for the OP periods. As a result, we get 12 pairs of productions and attractions (P's and A's) corresponding to each purpose and period combination of the trip distribution procedure are developed.

The result of this effort leads to the estimation of some 60-gamma functions for the different combinations of period, purpose and interchange category. Gamma functions were then applied to compute the seed matrices of a two-dimensional balancing model for year 1991. Results of the two-dimensional balancing were compared to those obtained with the three-dimensional balancing. This comparison confirmed that the gamma functions used to generate seed values of the two-dimensional balancing were efficient in implicitly applying the third dimension constraint of the three-dimensional balancing procedure. Then, the two-dimensional balancing strategy was applied to distribute the productions and attractions for the future year.

Internal-External Trip Distribution

Internal-external trip distribution refers to a process in which all internal and external, that is, all 1083 traffic analysis zone AWDT trips ends, are distributed using AWDT highway impedances, but only the trips with one end in an internal zone and other end in an external zone are retained. The term “internal-internal” distribution refers to a redistribution of the internal zone trip ends that the internal-external distribution matched with other internal zone trip ends. The trip ends are split into peak period trip ends and off-peak period trip ends. These trip ends are then distributed separately using mode choice derived log sums of disutilities, appropriately calculated to reflect either the peak period (combining AM and PM peak log-sums) or the off-peak period (combining midday and night log-sums).

At the core of the internal-external trip distribution is the EMME/2-based threedimensional balancing strategy, the third dimension incorporating the functions of constraining “k factors” and “f factors” which were carried over from our model set developed in UTPS software. This three dimensional balancing strategy performs a balancing of a seed matrix to zonal productions, zonal attractions, and subclass totals representing characteristics of the O-D trips of a transportation system, in this case, trip lengths as captured by highway impedances.

The basic output of the internal-external trip distribution model for the base year is an OD trip matrix, resulting from the third dimensional trip distribution as well as third dimension constraint and gamma functions. The base year inputs required for internal-external trip distribution include:

- Production and attractions matrixes by seven trip purposes output from the trip generation model: home-based work (wk); non home-based work (nw); non home-based other (nbo); school (sc); social-recreational (sr); shopping (sh); and pick-up and drop-off (pudo).

- The internal-external survey trip tables by purpose, which could only be coded at the 300 zone “land use’ level: one zone for each of twenty-three Boston and five Cambridge neighborhoods; one zone for each of the remaining towns; and one zone for each of the ninety-seven externals.
- The AWDT 1083-zone highway skims files, one for time in minutes and another for tolls in cents (from UTPS files). [Note: It was determined that a peak, off-peak factor split was unnecessary given their similarity within each trip purpose.

- Production and attraction terminal times. The terminal times were modeled (in UTPS) but then were modified at major external zones during the development of the UTPS internal-external distribution model. These elements were used to create AWDT highway impedances.

The core of future year forecasting is the two-dimensional balancing strategy. It consists of preparing a seed matrix, through application of the relevant gamma functions on scaled highway impedance values, and using the resulting seed matrix within a two-dimensional balancing procedure. For the future year, inputs required for internal-external trip distribution and pudo trip distribution include:

- Production and attractions matrixes by seven trip purposes output from the trip generation model: hone-based work (wk); non home-based work (nw); non homebased other (nbo); school (sc); social-recreational (sr); shopping (sh); and pick-up and drop-off (pudo).
- Production and attraction terminal times
- Nine gamma functions for each of six internal-external trip purposes computed from base year three dimensional balancing.
- Nine gamma functions for internal-external pudo trips computed from k and f factors derived from UTPS AGM module.
- Split factor matrices for allocating internal-external trips to four time periods based upon the 1991 external travel survey and the household survey
- SOV/HOV occupancy rates by time periods to allocate internal-external trips and internal-internal pudo trips.

Mode Choice Model

Mode choice models by trip purpose were developed using 1991 Household Travel Survey data, travel impedances obtained from highway and transit networks, 1990 and 2000 U.S. Census data and other data sources. There were not enough survey records for each chosen mode to estimate separate model parameters for home-based shopping/personal business and home-based social/recreational trips. Therefore, these two purposes were combined into one, and four mode choice models were developed. These were 1) home-based work and work related (HBW); 2) home-based other (HBO), which include home-based shopping, personal business, social, recreation and other miscellaneous purposes; 3) home-based school (HBSC) and 4) non home-based (NHB) trips. The available travel modes were: 1) walk-access transit, 2) drive-access transit 3) single-occupancy vehicles 4) high-occupancy vehicles (2 persons only for HBW trips) 5) high-occupancy vehicles with 3 or more persons (HBW trips only) and 6) walk. Specific transit mode selection, i.e. local bus, express bus, light rail, commuter rail, occurs during the transit assignment process.

Mode choice deals with intra-regional trips only. Trips to and from external areas are dealt with separately and assumed to be only auto trips. Mode choice results in a split of both inter-zonal and intra-zonal trips; however, intra-zonal are only split between the walk and auto modes (SOV, HOV/HOV2, and HOV3). The transit modes do not capture intra-zonal trips. The mode choice model variables are defined as follows:

Tree coefficient: This represents the combined utilities of the drive-access and walk-access components of the transit nest.

In-vehicle time: Time spent in a transit vehicle during the trip. For the shared-ride modes, in-vehicle and out-of-vehicle time are functions of drive alone time.

Out-of-vehicle time: Includes all walk and wait time and drive-access time, unless the last is specified separately.

Drive-access time: Time, by automobile, to drive from a trip origin to a transit station.

Terminal time: The time spent getting in a vehicle at the production end and entering the modeled highway network and the time spent leaving the modeled network and parking the vehicle and walking at the attraction end of the trip. These times are as high as five minutes in the Boston CBD and as low as one minute in suburban areas. They are assumed to remain constant in the future.

Fare: Transit fare, in dollars, including one-half of any park-and-ride charges (because fare per one-way trip is used). The adult cash fare is used because that is what is coded within the transit network. 2004 Fare policy is assumed to be in place in the future.

Auto cost: Auto operating cost in dollars, which is computed using 9.8 cents per mile (1991 dollars) and toll costs, if any. Also, one-half any applicable parking costs (because costs per one-way trip are used). Parking costs are computed at the district level based on the average parking costs reported by auto mode users in the 1991 House Hold travel survey. For shared ride modes, total costs are divided by the appropriate auto occupancy.

They are assumed to remain constant over time.

Household size: Persons per household. For 2025, population and household forecasts are provided by MAPC.

Vehicles/person: Total vehicles per person in the household. Vehicles are forecast for 2025 using the vehicle availability model described earlier.

Population density: Total population per acre.

Percent transit origins/destinations: The transit share of work trip ends in the TAZ, as computed by the home-based work mode choice model.

Work dummy: Equal to one, if the trip is work-related. Zero otherwise.

Input Data: The input files include: impedance matrices for each mode, the person trip tables to be split, pre-determined coefficients for utility equations and socioeconomic characteristics by TAZ.

Home Based Work Model

Home-based work (HBW) mode choice is the only trip purpose that distinguishes between two person carpools (HOV2) and three or more person carpools (HOV3). Formerly, travel on HOV lanes was restricted to HOV3 vehicles during peak hours. For the past several years, any 2-person vehicle may also use these facilities.

A transit nest is incorporated into the model on the basis that the decision to take transit over the other modes is done before selection of a particular transit mode. The transit coefficients are generic for both walk access (WAT) and drive access (DAT) and include a coefficient for in-vehicle, initial wait, transfer wait and total walk time. Drive access time and production terminal times are included in drive access transit as one parameter.

The HBW model utilizes two transit impedances that are exclusive to this trip purpose model, the WAT transfers and DAT transfers. Survey data indicate that the number of transfers is critical to mode selection for work trips. The WAT fare includes the transit fare in dollars. For DAT, fare includes the transit fare, any parking cost and the drive access cost, with the latter being computed as 9.8 cents per mile. Population density by traffic zone, in people per acre, is included in walk access transit, and is positively correlated so that the greater the density, the more likely a traveler is to choose this mode. The zones with high population densities also have more transit stops. Vehicles per worker is a socioeconomic input unique to this trip purpose for DAT. It is also positively correlated, since a higher vehicle per worker ratio increases the likelihood of taking a vehicle to a park-and-ride lot.

The auto times and costs are generic for the three auto modes. For HOV2, the auto cost is divided by 2 and for HOV3, it is divided by 3.66 to reflect splitting the cost between the vehicle occupants. Household size is included as a positively correlated variable for the shared-ride modes and has a somewhat greater impact for HOV3 than HOV2.

Home Based Other Model

The home-based other (HBO) mode choice model combines the home-based shopping and home-based recreational trip tables output from the trip distribution process into a single HBO trip table that is split. The model is similar to the HBW mode choice model, except for the following four differences. First, since there is only one shared ride mode, household size is only a parameter for shared ride two plus. Second, the vehicles per person in a household is used, as opposed to vehicles per worker. Third, the number of transfers in the transit modes was not found to be a significant variable and therefore was not included. Finally, a distance dummy equal to one if the trip distance was less than a mile, zero otherwise, was added to the walk mode. This reflects the fact that people taking short trips for this purpose are more likely to walk than choose another mode.

Home Based School

The home-based school (HBSC) model does not have separate utility equations for WAT and DAT, as there were not enough DAT trips for this purpose to develop a valid model. Therefore, one transit utility equation was developed and applied for splitting both WAT and DAT trips. The HBSC model has a non-motorized nest, meaning that people first choose whether they are going to walk or take a motorized mode. Following that decision, the secondary decision is whether to drive alone, carpool or take transit. The equation for transit contains in-vehicle travel time and one out-of-vehicle travel time made up of initial wait, transfer wait and walk time. If the transit path is a drive access path, auto access time and production terminal time are included in total out-of-vehicle time. The fare variable includes the transit fare, parking cost (if any), and auto access cost (if applicable).

Non Home Based Model

The non home-based (NHB) model splits work trips and non-work trips. There is a work dummy variable in the two auto modes which is equal to one if the trip is a non homebased work trip and zero otherwise. The coefficient is positive for SOV and negative for HOV. The percent of trips attracted to the origin and destination zones, which are SOV, is a variable in the drive alone mode. The percentage is taken from Journey-to-Work data and is positively correlated. Finally, the distance dummy in the walk mode is equal to one if the distance is less than a mile. It has a positive coefficient.

Pre Assignment Procedure (after Mode Choice)

The completion of the runs for the 16 mode choice applications (4 trip purposes by 4 time periods) results in the creation of 68-person trip tables. To prepare for subsequent highway and transit assignments, the trip tables must be converted from production-attraction to origin-destination formats (except for NHB trips where they are the same).

For the highway assignment it is necessary to convert person trips to vehicle trips by applying vehicle occupancy factors for HOV modes. These occupancy factors vary by trip purpose and, in the case of HBW trips a higher occupancy factor is applied to HOV3 trips. Their values are the following:

- home-based work trips HOV3 = 3.373
- home-based other trips HOV = 2.404
- home-based school trips HOV = 2.788
- non home-based trips HOV = 2.385

In addition to the manipulation of the output matrices from mode choice, it is necessary to bring in vehicle tables produced outside of the mode choice process. These include:

Trucks – The truck trip tables that have been used up to the present are based on 1963 survey data factored to the present.

External Through – This matrix includes trips that pass through the study area without stopping and hence are exogenous to the travel model. The trips were estimated from the 1991 external travel survey and have been factored since that time based upon production and attraction growth.

Taxi – The taxi vehicle trip table was originally developed from a 1993 survey and has been since revised several times based upon a factoring process. However, there has been no update of travel pattern data to create a true update trip table.

Logan Airport SOV & HOV – This trip table is developed from a separate modeling procedure, described in another section of the traffic model documentation.

Drive Access Transit Auto Access – DAT trips are determined through the mode choice process. Each DAT trip requires a vehicle access trip, with the total vehicle trips being slightly lower than the DAT total, as a small percentage of transit users carpool to park-and-ride-lots.

Internal-External SOV & HOV – The internal-external trip tables are generated through the trip distribution process.

Pickup/Drop-off SOV & HOV – The pickup/drop-off (PUDO) tables are those trips in which a person is dropped off at their destination (not an intermediate park-and-ride lot) by the driver. They are produced in the trip generation process along with other productions and attractions, then put through trip distribution.

Highway Assignment Model

The coding of the EMME/2 highway network basically follows the hierarchy of the functional classification system. Expressways, other than through denser urban areas, are generally coded for 60 mph speeds and hourly capacity per lane of 1950. Higher level arterials are coded for speeds ranging from 45 to 50 mph and corresponding capacities of 1050 to 1100. Lower level arterials and major collectors range from 35 mph to 40 mph, with capacities of 950 and 1000. Minor collectors and local streets that are not in urban centers range from 23 mph to 30 mph, with capacity generally at 800. Streets in urban centers can have substantially lower speeds and capacities.

The highway assignment utilizes the BPR function, which is a traditional procedure for planning models. This curve was based on the 1965 Highway Capacity Manual, which was parabolic in shape, and speed was fairly sensitive to increasing flows. The BPR curve is as follows:

Congested Speed = (Free-Flow Speed)/(1+0.15[volume/capacity]4)

For each time period the function is adjusted for apportioning the amount of demand to the number of hours. In the AM and PM peak periods, travel volume is apportioned to 3- hour periods, for the midday it is 6 hours and for the night it is 12 hours.

The highway assignment follows a straightforward procedure consisting of an equilibrium auto assignment. A multi-class assignment with generalized cost is applied. Generalized cost is computed as the combination of the travel time plus a fixed link cost. The multi-class assignment runs an assignment for the demand matrices of two modes, single occupancy vehicles and high occupancy vehicles from the vehicle trip tables for each class that are assigned by time period. Link tolls are contained in an extra attribute (@toll), which has average tolls along links where they are collected. A weight factor of five is applied to @toll to convert the cost in dollars to a time cost. This factor is based on an assumed value of time of $12.

The additional options assignment is then applied in order to compute output impedance matrices, including travel time, travel distance and tolls matrices. The travel time matrix output matrix is an optional output each time the assignment is run, but only one other impedance matrix per assignment can be produced. To output both the distance and toll matrices, the highway assignment must be run a second time. There is no vehicle occupancy factor to adjust the trip table, since this was already done when converting auto person trips to vehicle trips in the post-mode choice procedure. The additional demand to be assigned for additional volumes then is the same demand matrix applied to Class 1 – the SOV trip table. There are four attribute options available for the attribute matrix that is calculated. Additional path attribute is selected, which gives the average value of the path attribute for all the paths used in the assignment. The module then prompts the next class to be assigned, which is the HOV vehicle trip table. The HOV matrix for the particular time period is then specified. Since output impedance matrices are not calculated based on this demand, the prompt for the matrix to hold travel costs is bypassed. For the present model, the HOV is the final class for assignment, so the prompt for class 3 is bypassed.

The default number of iterations is 15; however the standard number used for assigning the CTPS regional model is 30. The model then asks for the stopping criteria for the relative gap. The relative gap is an estimate of the difference between the current assignment and a perfect equilibrium assignment, in which all paths used for a given O-D pair would have exactly the same time. The default is .5%, but .01% is selected, which should enable the full number of iterations to be carried out.

The other stopping criteria are the normalized gap (or trip time differential), which is the difference between the mean trip time of the current assignment and the mean minimal trip time. The mean trip time is the average trip time on the paths used in the previous iteration; the mean minimal trip time is the average trip time computed using the shortest paths of the current iteration. Again, a minimum level is selected, .01 minutes, in order for the designated number of iterations to be carried out. Note that the relative gap always decreases from one iteration to the next, whereas the trip time difference does not necessarily have this property. In a perfect equilibrium assignment, both the relative gap and the normalized gap are zero.

Transit Supply Model (Pre Trip Distribution)

The transit supply model is integral to the forecast of transit demand and the performance of different scenarios of infrastructure investment. Inter-zonal travel impedances faced by those trip makers who walk to their transit access points are the product of the transit system skimming process. This process contributes the transit portion of impedance to drive access transit skims as well. For this purpose the park and ride lots are regarded as special intermediate origin and destination zones.

The real network of commuter trains, ferries, rapid transit trains, local and express busses are represented digitally by an interconnected topology of infrastructure links. These links represent roadway and railway segments. Each link has a start node and an end node defined geographically with x-y coordinates. Each link also has a defined length and description as to which transit modes may traverse the link. In the case of commuter rail and rapid transit modes a link travel time in minutes is also defined. In our representation of the network, busses may traverse all highway links, but commuter rail and rapid rail transit use exclusive links only. They also use exclusive nodes. There is always a walk link between busses and trains. The transit network building conventions are explained below:

Transit Links and Lines: Bus lines are overlaid on highway links and rail links are coded separately. Sequences of transit links are defined together as lines. Each line is represented for each time period of the day with its own headway (frequency of service) and points of boarding and alighting. Each instance of a transit line traversing a transit link is a transit segment. Segments of the two rail modes take their travel time from the time of the link. Segments of the bus modes have transit times based on the scheduled line times apportioned by distance. Thus highway congestion doesn't directly affect bus travel times in the model. But if needed, bus speeds can be made a function of highway travel speeds. Future-year bus speeds are estimated on the basis of future-year congested highway speeds. The speeds of the various modes are determined on the basis of level-of- service data provided by the client and their consultants.

Walk-access Links: Walk-access times coded onto walk links represent the average walk time from all points in a zone to the transit node. These times were initially measured using the Arc/Info Geographic Information System (GIS) and then input to the EMME/2 transit network. Walking speed was assumed to be three miles per hour. The maximum walking distance used to connect a station to TAZ, regardless of mode is a mile.

Drive-access Path: A travel time is calculated from each internal TAZ to a PNR node. In order to calculate travel times, PNR nodes are considered TAZ's. Each park-and- ride node is connected to its associated transit node by a walk link. In the Boston core, no drive-access links are provided. The parking lot fare is coded directly on the link connecting the park-and-ride node to the station node. In cases where more than one parking lot serves a station, an average of their parking fee is coded.

Transfer Links: Transfer links are provided in the network where appropriate. For all downtown and some other rail stations, actual walking times from line to line were recently measured and these values are coded onto the transfer links.

Fare Coding Conventions: Fares were coded in the EMME/2 network at the appropriate transit nodes. Adult cash fares are used. Each mode is assigned a boarding fare and up to seven fare link codes. Because of the complexity of the area's fare system, not all private express bus, Green Line and Red Line (Braintree branch) fares are represented exactly as they occur. Park-and-ride parking charges are coded onto the walk link that connects the park-and-ride node to the transit station node.

Fares are given the value of $12 per hour or 1 minute for every 20 cents of fare. Boarding fares are imposed at transit nodes to represent local bus fares and rapid rail transit fares. Special coding procedures are followed at free transfer points. There, a penalty is imposed on walk access links instead. On commuter rail and express bus lines there are also fare penalties imposed on each segment traversed. Although fares are expressed in minutes to allow them to be impedances that influences path selection, they are not just lumped in with travel time.

Finally, each component of travel impedance is skimmed from the inter-zonal travel path separately and stored in its own inter-zonal matrix. Walk time is computed as link distance at three miles per hour. In the path selection process, the walk time is considered as twice the weight of in-vehicle travel time. Wait time is stored separately for the initial boarding and subsequent (transfer) boardings. The wait time is also factored in accordance with the characteristics of the transit mode being boarded. Each of these components of walk access transit impedance by time of day is input to the computation of drive access transit impedance and to the mode split process. They also become an element of the composite impedance upon which trip distribution is based.

Transit Assignment Model (post demand model)

After demand matrices of walk access and drive access transit trips have been forecast, these trips are assigned using our transit assignment model.
Drive access and walk access trips are combined by time period. The transit network and

other parameters are the same for assignment as for the impedance skimming process. Currently, congestion of passengers at stops and terminals does not influence travel times or behavior in the model.

Path Building Conventions

The transit assignment implemented in EMME/2 is a multi-path assignment, based on the computation of optimal strategies. The optimal strategy is one that minimizes the total expected perceived travel time. The values shown in Table 2 are currently being used in estimating the perceived travel times between a given origin and destination. These values apply both to walk-access transit and drive-access transit and to all sub-modes. They relate to in-vehicle time. For example, a transfer wait time factor of 2.45 implies that travelers perceive a minute of such time as 2.45 times more onerous than a minute spent riding in a transit vehicle. Although these values are theoretically supposed to correspond to marginal rates of substitution implicit in mode choice model coefficients, their final values are also based on what is needed to find reasonable paths through the network within the path-builder.

Finally, summaries of transit boardings by mode and time of day are produced along with boardings and alightings at stations for rapid rail transit and commuter rail, with subtotals by line. For busses, summaries of boardings by MBTA bus route number and time of day are produced.

III. TRAVEL MODEL CHANGES DUE TO FTA GUIDANCE

In preparing the Silver Line ridership forecasts in 2003 the FTA identified a number of modifications CTPS needed in order to make to the regional travel demand model calculate user benefits. These modifications were designed to allow CTPS's model to produce New Starts User Benefits consistent with FTA standards and the SUMMIT software. The modifications fell into three categories, FTA required changes, model input updates based on newer information, and model calibration adjustments.

The FTA changes included revisions to the path/skim/assignment parameters, development of new mode choice model coefficients and a standardization of the catchment areas for all transit stops to one mile, regardless of mode. CTPS took it upon itself to standardize transfer link lengths.

Path/Skim/Assignment Parameters

Previously, the network processing procedures used by CTPS weighted walk time by a factor of 2.0 as compared with in-vehicle time. Wait time was adjusted by a factor of 1.0 (i.e., it was un-weighted). Additionally, initial and transfer wait times were determined by multiplying the headway by the following mode-specific factors:

- Rapid transit and commuter rail south side = 0.3
- Commuter rail north side= 0.5
- Local and Express Bus = 0.9

Where free transfers were necessary, boarding fares were coded on walk access links in terms of equivalent minutes.

Ideally, wait time should be weighted by the same amount implied in the mode choice model. However, the EMME/2 optimal strategies path builder does not necessarily result in a path that is truly consistent with the mode choice model. This discrepancy meant that the wait time weight factor had to be reset to 2.0, the same as the walk time weight factor.

Several SUMMIT runs conducted by CTPS last year indicated that the different treatment of rapid transit, commuter rail, and bus headways with regards to transfer and wait time factors were causing problems leading to illogical User Benefit results. These parameters were originally used by CTPS to reflect the fact that passenger arrivals at rail services tend to be schedule-driven whereby customers consult a timetable and hence do not arrive at random intervals. On the other hand, buses tend to operate on frequent headways resulting in random passenger arrivals, giving an average wait time of one-half of a bus's headway.

To accommodate these characteristics and also to allow for consistent treatment of frequent rail service or infrequent bus service, we amended these procedures so that wait time is a function of headway and not mode. The following procedure has been used successfully in the New York and New Jersey transit forecasting models:

- Wait time=0.5*headway where: headway<15 minutes
- Wait time=7.5+0.25*(headway-15) where: 15 min.<headway<30 min.
- Wait time=12.25+0.125*(headway-30) where: headway>30 min.

This function is continuous and monotonically increasing, an important characteristics for consistent SUMMIT results.

This was attributed, at least in part, to the absence of a transfer penalty in the path builder parameters. A transfer penalty of 2.45 minutes was added to the model, which was the ratio of the original transfer coefficient in the HBW mode choice model to the adjusted transit in-vehicle travel time coefficient in the HBW mode choice model. When the bus ridership continued to be overestimated, a bus boarding penalty of 5 minutes was added to the model, reflecting the preference exhibited by riders for rail over bus (consistent with modal bias coefficients in mode choice models with separate bus and rail modes). To reflect an apparent sub-modal bias and allow for calibration of the local buses in the assignment rpocedures, a seven-minute penalty is now assigned for each bus boarding.

The resulting path choice parameters are as consistent with the mode choice model as possible.

Dropped all non-logit decision rules: Following FTA's order, all non-logit decision rules (such as capping wait times or ratios of out-of-vehicle/in-vehicle time ratios) have been eliminated from the model.

Mode Choice Model Coefficients

Mode choice coefficients for the CTPS mode choice model were re-specified to conform to FTA guidance for application with SUMMIT. In particular:

- In-Vehicle Travel Time (IVTT) coefficients are now consistent (at the top nest level) among modes or the differences are readily explainable
- Out-of-Vehicle Travel Time (OVTT) to IVTT ratios are now generally between three-to-one and two-to-one.
- Walk coefficients are now consistent between the walk-to-transit and walk-only modes

This has required some modification of the CTPS estimation results. The following sections describe the strategy used for adapting each model to conform to these requirements.

Home-Based Work

The home-based work model was adjusted as follows:

- The existing tree (nest) coefficient for transit of 0.6791 was retained.
- A generic IVTT coefficient was established as the average of the estimated coefficient for auto and transit (equivalent top nest value). The resulting coefficient is equal to -0.05466 at the top nest level.
- The existing terminal time coefficient is used. This yields a ratio of 5.4 to 1 with IVTT. Given that this variable acts principally as a CBD flag (there is no other similar flag), this variable was kept as is although production-end terminal time will be added to drive access transit for improved mode-to-mode consistency.
- The walk time coefficient is now based on the estimated walk time coefficient for the walk mode and applied in the revised model for both the walk mode and the walk-to-transit mode. This value (-0.1007 at the top level) has a ratio of 1.8 to1 with IVTT.
- The initial wait time coefficient is now based on the original initial wait time variable, adjusted to account for the change in wait time for buses described above (it was 0.9 times the headway but is now 0.5 times the headway). As such, the coefficient is factored upward by 1.8 as compared to the estimated model. The impact of headway on the utility function is unchanged for the predominant bus mode. The ratio of wait time to IVTT is now 2.07 to 1.
- The transfer wait coefficient was set to the same coefficient value as initial wait.

- The auto access time coefficient was set to 2.5 times in-vehicle time. This is higher than the originally estimated model, but is much less than the implied relationship incorporated in the station-choice model.
- The number of transfers coefficient was originally maintained at the same level as in the estimated model. The ratio to in-vehicle time declined to 2.45 minutes per transfer due to the increase in the transit in-vehicle time coefficient. Since the transfer time coefficient also increased substantially, any further increase in transfer penalty was hard to substantiate. However, when the bus-boarding penalty was adopted, the transfer variable was dropped and replaced by a boarding time variable. The IVTT coefficient was applied to the boarding time variable.
- The original cost coefficients were retained which are approximately equal to -0.32 for all modes (at the top level). This resulted in a $10.32 per hour value of time of which is generally consistent with other models in the Northeast.
- Various socioeconomic coefficient values were retained.

Table 2 in Appendix A presents the revised coefficient values.

Home-Based Other

- The existing tree (nest) coefficient of 0.3722 for transit was retained.
- A generic IVTT coefficient was established as the average of the estimated coefficient for auto and transit (top nest equivalent value). The resulting coefficient is equal to -0.01965 at the top nest level. This value is just below the FTA guidance of -0.02 to -0.03 and is also less than the HBW coefficient, which is reasonable.
- The existing terminal time coefficient, which yields a ratio of 11.74 to 1 with IVTT, was retained. Given that this variable acts principally as a CBD flag (there is no other similar flag) this variable was retained in its present form. The production-end terminal time will be added to drive access transit for improved mode-to-mode consistency.
- The walk time coefficient was originally based on the estimated walk time coefficient for the walk mode and applied in the revised model for both the walk mode and walk-to-transit mode. This value (-0.08239 at the top level) had a ratio of 4.19 to 1 with IVTT, so it was lowered to -.0589 (three times the in-vehicle travel time coefficient).
- The initial wait time coefficient was based on the original initial wait time variable, adjusted to account for the change in wait time for buses described above (it was 0.9 times the headway and is now 0.5 times the headway). As such, the coefficient was factored upward by 1.8, as compared with the estimated model. The impact of headway on the utility function is unchanged for the predominant bus mode. The ratio of wait time to IVTT was thus 4.23. The initial wait time coefficient was lowered to -.0589 (three times the in-vehicle travel time coefficient).
- The transfer wait coefficient was set equal to the initial wait coefficient.
- The auto access time coefficient was set to 2.5 times the coefficient for IVTT.

- The number of transfers coefficient was maintained at the same level as in the Home-Based Work model (2.45 minutes per transfer). This accounts for the significant reduction in the value of the transfer time coefficient. However, this variable was replaced by the boarding time variable (including a 2.45-minute penalty per transfer) which has the same coefficient as the IVTT variable.
- The original cost coefficient was defined as the average (at the top nest level) of the transit and automobile cost coefficients. This resulted in a value of time of $5.27 per hour, which is approximately half of the HBW value of time.
- Various socioeconomic coefficient values were retained.

The revised coefficient values are presented in Appendix A, Table 3.

Home-Based School

The nesting structure of the Home-Based School model (which lumps transit and drive access trips together in a motorized nest and walk trips in a separate non-motorized nest) was difficult to reconcile with the SUMMIT software's expectation of a transit v. non-transit nesting structure. Fully researching the best way to integrate the Home-Based School model structure with SUMMIT would be a very time consuming exercise. As there are relatively few Home-based School trips CTPS decided it was best to drop the Home-Based School trips from the User Benefit analyses altogether. This was accomplished by manually setting the build scenario trips and utilities equal to the baseline trips and utilities within SUMMIT.

Non-Home Based

- The existing multinomial structure was retained.
- A generic IVTT coefficient was established as the average of the estimated coefficient for auto and transit. The resulting value was -0.03022.
- The existing terminal time coefficient, which yields a ratio of 10.58 to 1 with IVTT, was retained. Given that this variable acts principally as a CBD flag (there is no other similar flag), this variable was retained in its present form. The production-end terminal time will be added to drive access transit for improved mode-to-mode consistency.
- The walk time coefficient is now based on the estimated walk time coefficient for the walk mode and applied in the revised model for both the walk mode and walk-to-transit mode. This value (-0.07525 at the top level) has a ratio of 2.49 to 1 with IVTT.
- The initial wait coefficient is now based on the initial wait coefficient from the alternate CTPS non-home based model (-0.08333). The ratio of wait time to in-vehicle time is now 2.75 to 1.
- The transfer wait coefficient was set equal to the initial wait coefficient.
- The auto access time coefficient was set to 2.5 times the IVTT coefficient.
- The number of transfers coefficient was originally maintained at the same level as in the Home-Based Work model (2.45 minutes per transfer). This accounted for the significant

reduction in the value of the transfer time coefficient. However, this variable was replaced by a boarding time variable (including a penalty of 2.45 minutes per transfer) which was set equal to the IVTT coefficient.

- The cost coefficients were set to equal the automobile cost coefficient. This resulted in a value of time of $9.87 per hour, which is approximately equal to the HBW value of time.
- Various socioeconomic coefficient values were retained.

Table 4 in Appendix A presents the recommended coefficient values.

Dropped parking supply constraints

Following FTA's direction, PNR supply constraints have been eliminated from the model.

IV. AIR QUALITY MODELING

The air quality impacts of alternative transportation scenarios can be analyzed using the standard traffic forecasting models. Our model estimates future traffic volumes, average highway speeds, vehicle miles and vehicle hours traveled within the transportation network at a highly disaggregate level. Since the amount of air pollution emitted by highway traffic depends on prevailing highway speeds and vehicle miles traveled on the network, it is now possible to estimate air quality impacts with reasonable accuracy.

Typically, we estimate three major pollutants emitted by autos, trucks, and transit: Carbon Monoxide (CO), Volatile Organic Compounds (VOC) and Nitrous Oxides (NOx). The model uses Mobile 6 emission factors to calculate these three pollutants on a link-by-link basis. Four components make up traffic pollution one of which is handled by the model. The remaining three is dealt with off model.

Handled off-model**:**

- The pollutants emitted by the diesel locomotives of the commuter rail system.
- The pollutants emitted by the MBTA bus system.
- The automobile pollution resulting from park and ride trips.

Handled within the model:

- Most auto and truck traffic

The pollutants from the above mentioned categories can be estimated outside of the model. The following paragraphs describe the general off-model procedure that was used to handle these categories.

The amount of a given pollutant that is produced by automobile traffic, excluding park-and-ride trips, is a function of three factors:

- Vehicle Miles Traveled (VMT)
- Speeds on the roadways
- Type of roadway
- Emission factor for the pollutants from MOBILE 6

The emission factor and roadways are constant in this study between the no-build and build alternatives. Observed emission changes are due to mode shifts from auto to transit, resulting in lower VMT and possibly lower congested speeds on the roadway network. Hence, the more auto diversions there are, the more likely the air quality measures will improve.

Off-model emissions were calculated by the consultant and described elsewhere in this report.

V. SUMMIT ANALYSIS

Background

The Federal Transit Administration (FTA) distributed the SUMMIT software tool in 2002 for the purpose of calculating User Benefits. The FTA in order to compare New Starts submissions from around the country decided to use User Benefit measure in the selection of projects to receive federal funding. The concept of User Benefits is based on consumer surplus, which reflects the difference in price or cost of travel for all modes and for all users in the transportation system, between two alternatives.

User Benefits are equal to all changes in times and costs for all modes—with the costs translated into equivalent time units so that they can be rolled in with actual time—that are associated with the provision of a particular transit service.

Travel forecasting models consider many variables in the process of determining how trips are made from one location to another. Variables such as time, transfers, and costs are all used by the mode-choice model to split person trips into transit, auto, and non-motorized modes. The regional travel demand model supplies this information to SUMMIT, which in turn converts them all into units of time.

Concept of Utility

User Benefits represent changes in the generalized cost of travel for individual travelers. For each proposed transit capital improvement project, cumulative or total User Benefits are calculated for a no-build or TSM alternative and a build alternative. These costs are collectively known in the mode-choice model as the utility of travel and this is calculated for each mode, namely auto, non-motorized, and transit. The following generalized costs are input into the mode choice model and are captured in the User Benefit calculation:

Auto Utility

- Tolls for autos
- Costs associated with parking
- Operating costs associated with an auto such as gas and insurance
- Travel times reflecting congestion on the roadways due to traffic

Transit Utility

- In-vehicle time: The accumulated travel time on board a transit vehicle
- Dwell time: The cumulative time riders spend in a vehicle while people board and alight
- Walking time to and from the station
- Driving time to and from a park-and-ride lot
- The time it takes to transfer to another mode or to another line in the same mode
- The time a person spends waiting for a transit vehicle
- Park-and-ride lot fees
- Number of transfers
- Transit fares

Costs are converted to time using a deflation factor and the assumption that the value of time is $12/hour.

Inputs

The Travel Demand Model data is broken down into time of day and purpose. This information is supplied for a no-build and build alternative. The time periods used are AM, Midday, PM, & Nighttime, and collectively they represent an average weekday. The purposes consist of Home-Based-Work, Home-Based-Other, and Non-Home Based. The CTPS regional travel demand model provides the following data as inputs into the SUMMIT User Benefit calculation.

- Total person trips
- Transit mode shares
- Auto utility
- Transit utility
- Access factors by market segment
- In-vehicle travel time coefficient for auto
- In-vehicle travel time coefficient for transit

Total person trips are all trips by purpose and time period that use one of three modes of travel in the regional transportation system.

Transit shares are the output of the mode choice model and represent the percentage of people who take transit from one location to another.Transit shares and the person trips are used to calculate the number of transit and auto trips, which are used in the calculation.

Auto and transit utilities were described earlier.

Access factors by market segments are how SUMMIT stratifies markets of person trips based on the type of access they have to the transit system.

- Can-walk represents the percentage of trips with respect to zone pairs that can walk to transit and then walk from transit to their destination.
- Must-drive represents the percentage of trips in a traffic zone that have access to transit via an automobile and cannot walk to transit.
- No-transit represents the percentage of all person trips not covered by the other two market segments.

The User Benefit calculation also includes the in-vehicle travel time coefficient used in the mode choice model for the auto and transit modes that were developed from travel survey data.

Application of User Benefits

A key purpose of implementing a new transit project is to improve the service and benefits provided to transit customers. There are many ways to express those benefits that may extend beyond the transit project itself and include such things as reduced congestion on area roadways and associated improvements in air quality. For its calculation of cost effectiveness, FTA has developed a standardized methodology for expressing benefits in terms of hours of User Benefits. These benefits, which come directly from the regional travel demand-forecasting model, encompass both hours of travel time saved by riders on the Red/Blue Connector and travel timesavings for transit riders using other MBTA services.

VI. ENVIRONMENTAL JUSTICE ANALYSIS

The study area encompasses environmental justice (EJ) neighborhoods, as defined by the Boston MPO, in three communities; Cambridge, Medford, and Somerville. In order to better understand the consequences of each scenario on the EJ neighborhoods in question the MBTA has requested CTPS to undertake an EJ assessment. The environmental justice assessment involves five steps:

1. Identify the *target populations* in the MPO that match the MPO definition of low-income and minority communities.
2. Determine what level of *geography* the results will be presented in.
3. Define the *modes* that will be used in the analysis.
4. Examine the relative *mobility* characteristics of the target areas within a scenario and between different scenarios at a systems-level.

5. Analyze the *accessibility* of target areas to selected destination types within a scenario and between different scenarios at a systems-level.

Target Populations

In order to help identify what the target populations should be and where they are located, the Environmental Justice Committee (EJC) used census data and personal insight in the criteria development. The populations initially considered were low income, non-English speaking, and minority population. Based on discussion within the EJC, low-income and minority populations were separated out for the study using the following definition.

> *Low-income target areas are defined as those with income less then 75% of the MPO median income. Minority population target areas were defines as populations with more than 21.4% of the community total. Statistical profiles, insight from EJ members, and suggestions from the CTPS can help perfect this list.*

The following terminology will be used to describe the population and areas being studied in this memo.

- Target populations - includes both low-income and minority populations
- Target groups – represents either the low-income or the minority population
- Target areas – defines all of the areas that have a given target group
- Target corridors/clusters – identifies groups of target zones
- Target zones – identifies the zones that have either low-income or minority populations located in them
- Target geography – This identifies the smallest level of geography used to determine what target populations are included in what target zones

Geography

This step will focus on how the data will be aggregated for the analysis. This aggregation will be based on TAZ's. Every targeted population will be identified with the TAZ that it is located in. For the mobility, accessibility, and equity analysis several key points relating to aggregation of TAZ's need to be considered.

- The analysis will be performed for the 101 communities within the Boston MPO Region, which is a subset of the 164 cities and towns in the modeled area.
- Target area locations won't change in the future year.
- The target areas will be grouped together within a scenario in order to develop the measures for the system-level analysis of mobility, accessibility, and equity; then these results will be compared with the build scenarios.

- To take into account the urban & suburban characteristics of the regions the MPO will be split geographically into two areas that take these characteristics into account.
- Target groups can be examined using target areas, target corridors, and target zone as units of analysis.
- A corridor/cluster level analysis will be performed if necessary to examine impacts on a limited number of selected groupings of TAZ's that the EJ C may decide are important to look at. The corridor/cluster will be used to examine homogenous areas with the MPO.
- An analysis of geography of target populations within a scenario and between different scenarios.

Modes

The regional model allows us to examine several different modes of transportation. The two these analysis will focus on are the auto and transit modes This methodology proposes that for each scenario we will look at the average auto times, average transit times, and average costs inherent in the modeling process incurred from a TAZ to the following:

- Within a scenario & between scenarios
- For the Regional Model study area
- By MPO region
- By urban and suburban areas
- By target areas
- For selected target corridors/clusters
- For selected target zones

Mobility Analysis

Mobility refers to the ease of movement of people, goods, and services across the region.
The mobility analysis involves two levels. The first involves presenting and comparing system-wide statistics related to the region's transportation system, several of which are listed below.

- Average weekday highway and transit travel time.
- Average mode split by geographic region.
- Average trip length for transit and auto trips.
- Total vehicle miles and vehicle hours of travel, made by all vehicles on a typical weekday in the entire eastern Massachusetts region and sub-regions.
- Average speed of traffic in the region.
- Daily traffic volumes on major freeways, expressways and arterials.
- Amount of air pollution produced by the automobile traffic, trains, and buses.

The second part of the mobility analysis will look at the average travel time and distances by mode. For the no-build scenario, several comparisons can be made within it based on the target group, geography, and by mode. The average travel time by mode for a target area can then be compared with the following average travel times.

- Regional Model Study Area
- MPO Region
- Urban and Suburban Areas
- Target areas & groups
- Selected target corridors/clusters
- Selected target zones

These comparisons are not independent of one-another but can be used together to refine the process. Target corridors/clusters or target zones can be compared within an urban / suburban geographic breakdown is one example.

The changes in travel time for each one of these dimensions within a scenario can be used a benchmark to compare with the build scenarios. A comparison can be made using anyone or a combination of the following:

- Statistical comparisons of average travel times
- Absolute differences between average travel times
- Relative differences between average travel times

This breakdown by geography and type of analysis can also be used to compare average trip distances for the target zones.

Accessibility Analysis

This analysis will quantify the accessibility of the selected origin target zones to selected destination zones. At a minimum, federal requirements ask us to look at destinations consisting of higher educational facilities, employment, and health care facilities. The measures used in this analysis will attempt to quantify the number of facilities available within a pre-determined travel time from any given target zone using the following approach.

Employment

1. Employment data is available for ten different sectors of the economy. These will be grouped together for (total employment) in this analysis. *Note: It is possible to look at specific types of employment if the EJC feels it is appropriate to group them or focus on only one sector . The types of employment consist of the following:*
    - Service employment
    - Government employment
    - Primary education
    - Secondary education
    - Financial, insurance, & real-estate
    - Retail &Wholesale
    - Manufacturing
    - Agriculture, mining, & construction
    - Transportation, communications, & utilities
2. The model will be used to estimate auto and transit travel times from each selected target zones to all TAZ's in the Regional Modeled Study Area.
3. The total employment within 10, 20, 30, or more minutes of each target zone for each zone and by mode will be presented for the no-build scenario.
4. The employment will be weighted by the size of the target group to develop an average number of employment opportunities available to that target group.
5. This will be repeated for the build scenarios and compared with the no-build.
6. Comparisons within a scenario and between scenarios by mode can be made using this information.

Higher educational Facilities

1. Higher educational facilities will be broken down into community colleges, other two-year institutions, and 4-year schools.
2. The model will be used to estimate auto and transit travel times from each selected target zones to all TAZ's in the Modeled Area.
3. The type of educational facility will be weighted in this analysis by its current enrollment in order to reflect the number of educational opportunities that it may have.
4. The total number of educational facilities within 10, 20, 30, or more minutes of each target zone and by mode will be presented for the no-build scenario.
5. This will be repeated for the build scenarios.
6. The enrollment will be weighted by the size of the target group to develop an average number of educational facilities available to that target group.
7. Comparisons within a scenario and between scenarios by mode can be made using this information.

Health Care Facilities

1. Locations of health care facilities will be based on what on the best available information is at the time of the analysis.
2. The model will be used to estimate auto and transit travel times from each selected target zones to all TAZ's in the Regional Modeled Study Area.
3. The total numbers of health care facilities within 10, 20, 30, or more minutes of each target zone and by mode will be presented for the no-build scenario.
4. This will be repeated for the build scenarios.
5. The number of health care facilities will be weighted by the size of the target group to develop an average number of health care facilities available to that target group.
6. Comparisons within a scenario and between scenarios by mode can be made using this information.

APPENDIX A

TABLE 2
Home-Based Work Mode Choice Model Specification

		Impedance Variables									Socio-Economic Variables		
Home-Based Work	Nest Coeff	IVTT	Terminal Time	Walk Time	Initial Wait	Transfer Wait	Auto Access	Boarding Time	Fare ($)	Auto Cost ($)	Population. Density	Vehicles/ Worker	HHld Size
Drive Alone													
Top Level	1	-0.05466	-0.292							-0.32			
Application Level		-0.05466	-0.292							-0.32			
Ratio to IVTT/VOT ($/hr)		1	5.34211							$ 10.25			
SR2													
Top Level	1	-0.05466	-0.292							-0.32			0.07322
Application Level		-0.05466	-0.292							-0.32			0.07322
Ratio to IVTT/VOT ($/hr)		1	5.34211							$ 10.25			-1.33955
SR3+													
Top Level	1	-0.05466	-0.292							-0.32			0.2168
Application Level		-0.05466	-0.292							-0.32			0.2168
Ratio to IVTT/VOT ($/hr)		1	5.34211							$ 10.25			-3.96634
Walk													
Top Level	1			-0.1007									
Application Level				-0.1007									
Ratio to IVTT/VOT ($/hr)													
Walk-Transit													
Top Level	0.6791	-0.05466		-0.1007	-0.11292	-0.11292		-0.05466	-0.32		0.01889		
Application Level		-0.08049		-0.14828	-0.16628	-0.16628		-0.08049	-0.47121		0.02781		
Ratio to IVTT/VOT ($/hr)		1		1.8423	2.06593	2.06593		1	$ 10.25		-0.34551		
Drive-Transit													
Top Level	0.6791	-0.05466	-0.292	-0.1007	-0.11292	-0.11292	-0.13665	-0.05466	-0.32	-0.32		0.2897	
Application Level		-0.08049	-0.42998	-0.14828	-0.16628	-0.16628	-0.20122	-0.08049	-0.47121	-0.47121		0.4266	
Ratio to IVTT/VOT ($/hr)		1	5.34211	1.8423	2.06593	2.06593	2.5	1	$ 10.25	$ 10.25		-5.30011	

APPENDIX A

TABLE 3
Home-Based Other Mode Choice Model Specification

		Impedance Variables									Socio-Economic Variables			
Home-Based Other	Nest Coefficient	IVTT	Terminal Time	Walk Time	Initial Wait	Transfer Wait	Auto Access	Boarding Time	Fare ($)	Auto Cost ($)	Population. Density	Vehicles/ Worker	HHld Size	Distance Dummy
Drive Alone														
Top Level	1	-0.01965	-0.2308							-0.22378				
Application Level		-0.01965	-0.2308							-0.22378				
Ratio to IVTT/VOT ($/hr)		1	11.7463							$ 5.27				
SR2+														
Top Level	1	-0.01965	-0.2308							-0.22378			0.1976	
Application Level		-0.01965	-0.2308							-0.22378			0.1976	
Ratio to IVTT/VOT ($/hr)		1	11.7463							$ 5.27			-10.0566	
Walk														
Top Level	1			-0.05895										0.9005
Application Level				-0.05895										0.9005
Ratio to IVTT/VOT ($/hr)														-15.2757
Walk-Transit														
Top Level	0.3722	-0.01965		-0.05895	-0.05895	-0.05895		-0.01965	-0.22378		0.00883			
Application Level		-0.05279		-0.15838	-0.15838	-0.15838		-0.05279	-0.60123		0.02373			
Ratio to IVTT/VOT ($/hr)		1		3.0002	3.0002	3.0002		1	$ 5.27		-0.44951			
Drive-Transit														
Top Level	0.3722	-0.01965	-0.2308	-0.05895	-0.05895	-0.05895	-0.04912	-0.01965	-0.22378	-0.22378		0.71239		
Application Level		-0.05279	-0.6201	-0.15838	-0.15838	-0.15838	-0.13198	-0.05279	-0.60123	-0.60123		1.914		
Ratio to IVTT/VOT ($/hr)		1	11.7463	3.0002	3.0002	3.0002	2.5	1	$ 5.27	$ 5.27		-36.2564		

APPENDIX A

TABLE 4
Non-home Based Work Mode Choice Model Specification

		Impedance Variables									Socio-Economic Variables		
Non-Home-Based	Nest Coefficient	IVTT	Terminal Time	Walk Time	Initial Wait	Transfer Wait	Auto Access	Boarding Time	Fare ($)	Auto Cost ($)	Work Dummy	Distance Dummy	Percent SOV
Drive Alone													
Top Level	1	-0.03022	-0.3197							-0.1817	0.1926		0.00885
Application Level		-0.03022	-0.3197							-0.1817	0.1926		0.00885
Ratio to IVTT/VOT ($/hr)		1	10.5791							$ 9.98	-6.37326		-0.29295
SR2+													
Top Level	1	-0.03022	-0.3197							-0.1817	-0.7627		
Application Level		-0.03022	-0.3197							-0.1817	-0.7627		
Ratio to IVTT/VOT ($/hr)		1	10.5791							$ 9.98	25.2383		
Walk													
Top Level	1			-0.07525								0.493	
Application Level				-0.07525								0.493	
Ratio to IVTT/VOT ($/hr)												-6.5515	
Walk-Transit													
Top Level	1	-0.03022		-0.07525	-0.08333	-0.08333		-0.03022	-0.1817				
Application Level		-0.03022		-0.07525	-0.08333	-0.08333		-0.03022	-0.1817				
Ratio to IVTT/VOT ($/hr)		1		2.49007	2.75745	2.75745		1	$ 9.98				
Drive-Transit													
Top Level	1	-0.03022	-0.3197	-0.07525	-0.08333	-0.08333	-0.07555	-0.03022	-0.1817	-0.1817			
Application Level		-0.03022	-0.3197	-0.07525	-0.08333	-0.08333	-0.07555	-0.03022	-0.1817	-0.1817			
Ratio to IVTT/VOT ($/hr)		1	10.5791	2.49007	2.75745	2.75745	2.5	1	$ 9.98	$ 9.98			

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Appendix F

CTPS Travel Demand Model Detailed Results

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Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	Base Year (2003)				
	AM	**MD**	**PM**	**NT**	**Daily**
Linked Person Transit Trips	**243,310**	**323,630**	**257,670**	**182,270**	**1,006,880**
Walk Access	198,500	292,950	207,480	164,860	863,790
Drive Access	44,810	30,680	50,190	17,410	143,090
Auto Person Trips	1,641,180	3,908,230	2,633,050	3,050,740	11,233,200
Walking Person Trips	326,240	937,740	479,130	523,510	2,266,620
Total Person Trips	2,210,730	5,169,600	3,369,850	3,756,520	14,506,700
Transit Mode Share	11.01%	6.26%	7.65%	4.85%	6.94%
Unlinked Transit Trips	**332,120**	**429,850**	**348,560**	**233,390**	**1,343,920**
Commuter Rail System	**41,150**	**22,220**	**40,720**	**9,670**	**113,760**
North Side	**16,080**	**11,450**	**15,390**	**3,990**	**46,910**
Newburyport/Rockport	6,870	4,830	6,190	1,270	19,160
Haverhill	4,350	2,440	3,700	1,110	11,600
Lowell	2,050	1,890	2,220	720	6,880
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	2,810	2,290	3,280	890	9,270
South Side	**25,070**	**10,770**	**25,330**	**5,680**	**66,850**
Framingham	5,170	2,780	5,120	1,190	14,260
Needham	1,910	870	1,720	970	5,470
Fairmont	1,250	1,410	2,050	370	5,080
Franklin	3,650	1,500	4,430	980	10,560
Attleboro	2,950	1,450	2,250	930	7,580
Stoughton	1,990	900	2,710	730	6,330
Middleboro	4,020	900	3,820	270	9,010
Plymouth	4,130	960	3,230	240	8,560
Greenbush	na	na	na	na	na
Rapid Transit System	**187,860**	**266,220**	**207,010**	**151,270**	**812,360**
Blue	19,100	20,260	19,880	9,580	68,820
Orange	43,890	49,240	48,030	22,020	163,180
Red	67,700	96,580	75,640	57,250	297,170
Green	57,170	100,140	63,460	62,420	283,190
Bus & Ferry System	**103,110**	**141,410**	**100,830**	**72,450**	**417,800**
Local	79,790	126,070	78,500	63,750	348,110
Express Buses & Ferries	19,150	11,280	19,710	7,850	57,990
Bus Rapid Transit	4,170	4,060	2,620	850	11,700
Transfer Rate	**1.37**	**1.33**	**1.35**	**1.28**	**1.33**
Summit Results in Hours of User Benefits	**na**	**na**	**na**	**na**	**na**
Passenger Miles	**1,589,854**	**1,544,954**	**1,565,854**	**824,534**	**5,525,196**
Avg. IV Transit Trip Length in Miles	4.79	3.59	4.49	3.53	4.11
Passenger Hours	**91,127**	**97,994**	**90,745**	**49,182**	**329,048**
Avg. IV Transit Trip Time in Minutes	16.46	13.68	15.62	12.64	14.69
Daily Adult Cash Fare	**$ 454,195**	**$ 469,382**	**$ 457,868**	**$ 256,283**	**$ 1,637,728**
Avg. Fare per Linked Trip	0.536	0.689	0.563	0.711	0.615

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	**NBLD (2025)**				
	AM	**MD**	**PM**	**NT**	**Daily**
Linked Person Transit Trips	**305,660**	**398,120**	**330,210**	**226,170**	**1,260,160**
Walk Access	255,880	360,800	270,090	206,670	1,093,440
Drive Access	49,780	37,320	60,120	19,500	166,720
Auto Person Trips	1,719,780	4,397,390	2,864,440	3,318,480	12,300,090
Walking Person Trips	356,980	1,085,480	551,030	614,220	2,607,710
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.83%	6.77%	8.82%	5.44%	7.79%
Unlinked Transit Trips	**436,240**	**540,890**	**467,610**	**300,130**	**1,744,870**
Commuter Rail System	**55,690**	**26,770**	**57,430**	**12,030**	**151,920**
North Side	**20,580**	**12,680**	**21,070**	**4,370**	**58,700**
Newburyport/Rockport	6,620	4,480	7,640	1,090	19,830
Haverhill	5,640	2,830	4,730	1,070	14,270
Lowell	3,520	2,350	3,360	910	10,140
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,800	3,020	5,340	1,300	14,460
South Side	**35,110**	**14,090**	**36,360**	**7,660**	**93,220**
Framingham	7,380	3,170	7,320	1,440	19,310
Needham	2,220	900	2,000	1,040	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,510	960	12,410
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	770	7,550
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	330	10,310
Greenbush	2,190	400	2,040	210	4,840
Rapid Transit System	**191,460**	**270,130**	**214,840**	**156,670**	**833,100**
Blue	19,900	19,220	21,100	10,320	70,540
Orange	43,740	50,240	52,110	20,210	166,300
Red	67,800	99,400	76,990	58,210	302,400
Green	60,020	101,270	64,640	67,930	293,860
Bus & Ferry System	**189,090**	**243,990**	**195,340**	**131,430**	**759,850**
Local	97,440	147,890	98,460	85,210	429,000
Express Buses & Ferries	28,920	17,220	27,540	8,430	82,110
Bus Rapid Transit	62,730	78,880	69,340	37,790	248,740
Transfer Rate	**1.43**	**1.36**	**1.42**	**1.33**	**1.38**
Summit Results in Hours of User Benefits	**na**	**na**	**na**	**na**	**na**
Passenger Miles	**2,187,330**	**1,928,790**	**2,170,150**	**982,760**	**7,269,030**
Avg. IV Transit Trip Length in Miles	5.01	3.57	4.64	3.27	4.17
Passenger Hours	**123,790**	**121,180**	**122,560**	**61,290**	**428,820**
Avg. IV Transit Trip Time in Minutes	17.03	13.44	15.73	12.25	14.75
Daily Adult Cash Fare	**$ 603,304**	**$ 586,309**	**$ 629,731**	**$ 315,991**	**$ 2,135,334**
Avg. Fare per Linked Trip	0.507	0.679	0.524	0.716	0.590

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	TSM (2025)				
	AM	MD	PM	NT	Daily
Linked Person Transit Trips	**306,040**	**398,320**	**330,710**	**226,670**	**1,261,740**
Walk Access	256,260	360,990	270,600	207,180	1,095,030
Drive Access	49,780	37,330	60,110	19,490	166,710
Auto Person Trips	1,719,450	4,397,190	2,864,030	3,318,030	12,298,700
Walking Person Trips	356,930	1,085,480	550,940	614,170	2,607,520
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.85%	6.77%	8.83%	5.45%	7.80%
Unlinked Transit Trips	**436,750**	**541,150**	**468,320**	**300,730**	**1,746,950**
Commuter Rail System	**55,630**	**26,740**	**57,340**	**11,960**	**151,670**
North Side	**20,520**	**12,650**	**20,980**	**4,300**	**58,450**
Newburyport/Rockport	6,610	4,480	7,630	1,090	19,810
Haverhill	5,630	2,830	4,720	1,070	14,250
Lowell	3,500	2,320	3,330	870	10,020
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,780	3,020	5,300	1,270	14,370
South Side	**35,110**	**14,090**	**36,360**	**7,660**	**93,220**
Framingham	7,380	3,170	7,320	1,440	19,310
Needham	2,220	900	2,000	1,040	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,510	960	12,410
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	770	7,550
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	330	10,310
Greenbush	2,190	400	2,040	210	4,840
Rapid Transit System	**191,140**	**269,900**	**214,600**	**156,290**	**831,930**
Blue	19,890	19,220	21,100	10,320	70,530
Orange	43,700	50,170	52,070	20,000	165,940
Red	67,590	99,270	76,830	58,010	301,700
Green	59,960	101,240	64,600	67,960	293,760
Bus & Ferry System	**189,980**	**244,510**	**196,380**	**132,480**	**763,350**
Local	98,300	148,410	99,580	86,500	432,790
Express Buses & Ferries	28,890	17,220	27,500	8,430	82,040
Bus Rapid Transit	62,790	78,880	69,300	37,550	248,520
Transfer Rate	**1.43**	**1.36**	**1.42**	**1.33**	**1.38**
Summit Results in Hours of User Benefits	**170**	**50**	**220**	**260**	**700**
Passenger Miles	**2,188,400**	**1,929,210**	**2,171,300**	**983,460**	**7,272,370**
Avg. IV Transit Trip Length in Miles	5.01	3.57	4.64	3.27	4.16
Passenger Hours	**123,890**	**121,250**	**122,680**	**61,390**	**429,210**
Avg. IV Transit Trip Time in Minutes	17.02	13.44	15.72	12.25	14.74
Daily Adult Cash Fare	**$ 603,487**	**$ 586,401**	**$ 630,065**	**$ 316,308**	**$ 2,136,261**
Avg. Fare per Linked Trip	0.507	0.679	0.525	0.717	0.591

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	Green Line to W. Medford (2025)				
	AM	MD	PM	NT	Daily
Linked Person Transit Trips	**307,770**	**402,550**	**333,770**	**230,230**	**1,274,320**
Walk Access	257,670	364980	272,930	210420	1,106,000
Drive Access	50,100	37,570	60,840	19,810	168,320
Auto Person Trips	1,717,800	4,393,110	2,861,160	3,314,700	12,286,770
Walking Person Trips	356,850	1,085,330	550,750	613,940	2,606,870
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.92%	6.84%	8.91%	5.54%	7.88%
Unlinked Transit Trips	**437,090**	**543,610**	**470,550**	**302,730**	**1,753,980**
Commuter Rail System	**55,460**	**26,230**	**56,870**	**11,620**	**150,180**
North Side	**20,340**	**12,130**	**20,490**	**3,930**	**56,890**
Newburyport/Rockport	6,600	4,480	7,630	1,090	19,800
Haverhill	5,650	2,840	4,740	1,080	14,310
Lowell	3,420	1,920	2,930	640	8,910
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,670	2,890	5,190	1,120	13,870
South Side	**35,120**	**14,100**	**36,380**	**7,690**	**93,290**
Framingham	7,390	3,180	7,320	1,450	19,340
Needham	2,220	900	2,010	1,030	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,520	970	12,430
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	780	7,560
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	340	10,320
Greenbush	2,190	400	2,040	210	4,840
Rapid Transit System	**197,590**	**282,270**	**223,670**	**164,960**	**868,490**
Blue	19,990	19,550	21,430	10,630	71,600
Orange	42,160	47,170	49,830	18,110	157,270
Red	63,970	92,040	72,660	53,210	281,880
Green	71,470	123,510	79,750	83,010	357,740
Bus & Ferry System	**184,040**	**235,110**	**190,010**	**126,150**	**735,310**
Local	93,860	141,110	94,930	80,630	410,530
Express Buses & Ferries	28,080	17,310	27,210	8,520	81,120
Bus Rapid Transit	62,100	76,690	67,870	37,000	243,660
Transfer Rate	**1.42**	**1.35**	**1.41**	**1.31**	**1.38**
Summit Results in Hours of User Benefits	**1,600**	**4,520**	**2,500**	**3,850**	**12,470**
Passenger Miles	**2,199,020**	**1,957,950**	**2,190,730**	**1,004,040**	**7,351,740**
Avg. IV Transit Trip Length in Miles	5.03	3.60	4.66	3.32	4.19
Passenger Hours	**124,590**	**123,080**	**123,870**	**62,470**	**434,010**
Avg. IV Transit Trip Time in Minutes	17.10	13.58	15.79	12.38	14.85
Daily Adult Cash Fare	**$ 606,386**	**$ 594,740**	**$ 636,278**	**$ 321,637**	**$ 2,159,040**
Avg. Fare per Linked Trip	0.508	0.677	0.525	0.716	0.590

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	**Green Line to W. Medford & Union Sq (2025)**				
	AM	**MD**	**PM**	**NT**	**Daily**
Linked Person Transit Trips	**307,390**	**400,810**	**333,110**	**228,910**	**1,270,220**
Walk Access	257,380	363,660	272,410	209,310	1,102,760
Drive Access	50,010	37,150	60,700	19,600	167,460
Auto Person Trips	1,718,130	4,394,670	2,861,730	3,315,900	12,290,430
Walking Person Trips	356,900	1,085,510	550,840	614,060	2,607,310
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.90%	6.82%	8.89%	5.50%	7.86%
Unlinked Transit Trips	**436,320**	**540,290**	**469,550**	**300,310**	**1,746,470**
Commuter Rail System	**55,490**	**26,250**	**56,930**	**11,620**	**150,290**
North Side	**20,380**	**12,160**	**20,560**	**3,950**	**57,050**
Newburyport/Rockport	6,600	4,470	7,630	1,090	19,790
Haverhill	5,640	2,830	4,740	1,080	14,290
Lowell	3,410	1,900	2,910	630	8,850
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,730	2,960	5,280	1,150	14,120
South Side	**35,110**	**14,090**	**36,370**	**7,670**	**93,240**
Framingham	7,380	3,170	7,320	1,440	19,310
Needham	2,220	900	2,010	1,030	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,510	970	12,420
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	780	7,560
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	330	10,310
Greenbush	2,190	400	2,040	210	4,840
Rapid Transit System	**196,680**	**278,130**	**222,810**	**162,180**	**859,800**
Blue	19,980	19,480	21,410	10,560	71,430
Orange	42,410	48,110	50,290	18,250	159,060
Red	64,130	92,780	72,690	53,730	283,330
Green	70,160	117,760	78,420	79,640	345,980
Bus & Ferry System	**184,150**	**235,910**	**189,810**	**126,510**	**736,380**
Local	94,270	142,470	95,080	81,180	413,000
Express Buses & Ferries	28,090	17,270	27,170	8,490	81,020
Bus Rapid Transit	61,790	76,170	67,560	36,840	242,360
Transfer Rate	**1.42**	**1.35**	**1.41**	**1.31**	**1.37**
Summit Results in Hours of User Benefits	**1,300**	**2,740**	**2,030**	**2,580**	**8,650**
Passenger Miles	**2,197,400**	**1,948,030**	**2,187,130**	**997,250**	**7,329,810**
Avg. IV Transit Trip Length in Miles	5.04	3.61	4.66	3.32	4.20
Passenger Hours	**124,530**	**122,520**	**123,680**	**62,130**	**432,860**
Avg. IV Transit Trip Time in Minutes	17.12	13.61	15.80	12.41	14.87
Daily Adult Cash Fare	**$ 605,644**	**$ 591,577**	**$ 635,123**	**$ 319,590**	**$ 2,151,933**
Avg. Fare per Linked Trip	0.508	0.678	0.524	0.716	0.590

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	W. Medford BRT to Lechmere & Green to Union Sq (2025)				
	AM	MD	PM	NT	Daily
Linked Person Transit Trips	**307,400**	**401,380**	**332,920**	**229,050**	**1,270,750**
Walk Access	257,260	363,980	272,220	209,340	1,102,800
Drive Access	50,140	37,400	60,700	19,710	167,950
Auto Person Trips	1,718,200	4,394,280	2,861,990	3,315,860	12,290,330
Walking Person Trips	356,820	1,085,330	550,770	613,960	2,606,880
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.90%	6.83%	8.89%	5.51%	7.86%
Unlinked Transit Trips	**442,450**	**551,020**	**475,140**	**307,560**	**1,776,170**
Commuter Rail System	**55,600**	**26,380**	**56,960**	**11,770**	**150,710**
North Side	**20,490**	**12,290**	**20,600**	**4,100**	**57,480**
Newburyport/Rockport	6,600	4,480	7,620	1,090	19,790
Haverhill	5,640	2,830	4,730	1,080	14,280
Lowell	3,440	1,940	2,930	640	8,950
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,810	3,040	5,320	1,290	14,460
South Side	**35,110**	**14,090**	**36,360**	**7,670**	**93,230**
Framingham	7,380	3,170	7,320	1,440	19,310
Needham	2,220	900	2,010	1,030	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,510	970	12,420
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	780	7,560
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	330	10,310
Greenbush	2,190	400	2,030	210	4,830
Rapid Transit System	**192,800**	**273,550**	**216,930**	**159,060**	**842,340**
Blue	19,960	19,430	21,330	10,510	71,230
Orange	42,490	48,390	50,690	18,310	159,880
Red	63,900	92,970	72,750	53,840	283,460
Green	66,450	112,760	72,160	76,400	327,770
Bus & Ferry System	**194,050**	**251,090**	**201,250**	**136,730**	**783,120**
Local	94,260	141,510	95,230	80,920	411,920
Express Buses & Ferries	28,250	17,270	27,280	8,490	81,290
Bus Rapid Transit	71,540	92,310	78,740	47,320	289,910
Transfer Rate	**1.44**	**1.37**	**1.43**	**1.34**	**1.40**
Summit Results in Hours of User Benefits	**1,040**	**2,960**	**1,670**	**2,410**	**8,080**
Passenger Miles	**2,197,120**	**1,947,220**	**2,184,720**	**995,420**	**7,324,480**
Avg. IV Transit Trip Length in Miles	4.97	3.53	4.60	3.24	4.12
Passenger Hours	**124,710**	**122,810**	**123,700**	**62,370**	**433,590**
Avg. IV Transit Trip Time in Minutes	16.91	13.37	15.62	12.17	14.65
Daily Adult Cash Fare	**$ 606,080**	**$ 593,170**	**$ 635,319**	**$ 320,269**	**$ 2,154,838**
Avg. Fare per Linked Trip	0.507	0.677	0.524	0.715	0.590

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	CRR Shuttle to W. Medford (2025)				
	AM	MD	PM	NT	Daily
Linked Person Transit Trips	**306,100**	**398,590**	**330,710**	**226,420**	**1,261,830**
Walk Access	256,080	361,090	270,300	206,830	1,094,310
Drive Access	50,020	37,500	60,410	19,590	167,520
Auto Person Trips	1,719,350	4,396,940	2,863,950	3,318,240	12,298,480
Walking Person Trips	356,970	1,085,460	551,020	614,210	2,607,650
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.85%	6.78%	8.83%	5.44%	7.80%
Unlinked Transit Trips	**436,950**	**541,460**	**468,340**	**300,370**	**1,747,110**
Commuter Rail System	**56,410**	**27,270**	**58,120**	**12,230**	**154,030**
North Side	**21,300**	**13,180**	**21,760**	**4,570**	**60,810**
Newburyport/Rockport	6,620	4,480	7,640	1,090	19,830
Haverhill	5,580	2,800	4,680	1,060	14,110
Lowell	3,240	2,160	3,090	840	9,340
West Medford Shuttle	1,100	740	1,050	290	3,180
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,760	3,000	5,300	1,290	14,350
South Side	**35,110**	**14,090**	**36,360**	**7,660**	**93,220**
Framingham	7,380	3,170	7,320	1,440	19,310
Needham	2,220	900	2,000	1,040	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,510	960	12,410
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	770	7,550
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	330	10,310
Greenbush	2,190	400	2,040	210	4,840
Rapid Transit System	**191,650**	**270,410**	**215,060**	**156,830**	**833,950**
Blue	19,910	19,230	21,110	10,330	70,590
Orange	43,820	50,330	52,200	20,250	166,590
Red	67,820	99,440	77,020	58,230	302,510
Green	60,100	101,410	64,730	68,020	294,260
Bus & Ferry System	**188,890**	**243,780**	**195,160**	**131,310**	**759,130**
Local	97,290	147,660	98,310	85,080	428,340
Express Buses & Ferries	28,800	17,150	27,430	8,400	81,770
Bus Rapid Transit	62,800	78,970	69,420	37,830	249,020
Transfer Rate	**1.43**	**1.36**	**1.42**	**1.33**	**1.38**
Summit Results in Hours of User Benefits	**51**	**43**	**56**	**20**	**170**
Passenger Miles	**2,202,230**	**2,041,300**	**2,243,350**	**1,006,240**	**7,493,120**
Avg. IV Transit Trip Length in Miles	5.04	3.77	4.79	3.35	4.29
Passenger Hours	**125,260**	**122,730**	**123,330**	**61,980**	**433,300**
Avg. IV Transit Trip Time in Minutes	17.2	13.6	15.8	12.4	14.88
Daily Adult Cash Fare	**$ 604,172**	**$ 587,001**	**$ 630,684**	**$ 316,340**	**$ 2,138,197**
Avg. Fare per Linked Trip	0.507	0.679	0.524	0.716	0.590

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Results

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	**CRR Shuttle to Anderson RTC (2025)**				
	AM	**MD**	**PM**	**NT**	**Daily**
Linked Person Transit Trips	**306,550**	**398,830**	**331,290**	**226,960**	**1,262,050**
Walk Access	256,470	361,280	270,820	207,350	1,094,330
Drive Access	50,080	37,550	60,470	19,610	167,720
Auto Person Trips	1,718,950	4,396,700	2,863,460	3,317,750	12,296,860
Walking Person Trips	356,920	1,085,460	550,930	614,160	2,607,650
Total Person Trips	2,382,420	5,880,990	3,745,680	4,158,870	16,167,960
Transit Mode Share	12.87%	6.78%	8.84%	5.46%	7.81%
Unlinked Transit Trips	**437,570**	**541,770**	**470,300**	**301,620**	**1,747,430**
Commuter Rail System	**56,420**	**27,290**	**59,280**	**12,820**	**154,220**
North Side	**21,310**	**13,200**	**22,920**	**5,160**	**61,000**
Newburyport/Rockport	6,610	4,480	7,630	1,090	19,830
Haverhill	5,530	2,780	4,670	1,060	14,010
Lowell	2,020	1,340	3,070	800	5,840
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	2,410	1,600	2,290	950	6,970
Fitchburg	4,740	3,000	5,260	1,260	14,350
South Side	**35,110**	**14,090**	**36,360**	**7,660**	**93,220**
Framingham	7,380	3,170	7,320	1,440	19,310
Needham	2,220	900	2,000	1,040	6,160
Fairmont	4,060	2,700	3,660	1,660	12,080
Franklin	4,190	1,750	5,510	960	12,410
Attleboro	3,840	1,730	3,400	970	9,940
Stoughton	2,190	980	3,610	770	7,550
Middleboro	4,600	1,070	4,670	280	10,620
Plymouth	4,440	1,390	4,150	330	10,310
Greenbush	2,190	400	2,040	210	4,840
Rapid Transit System	**191,390**	**270,180**	**214,820**	**156,440**	**834,140**
Blue	19,910	19,230	21,110	10,330	70,600
Orange	43,800	50,260	52,160	20,030	166,690
Red	67,620	99,310	76,860	58,030	302,520
Green	60,060	101,380	64,690	68,050	294,330
Bus & Ferry System	**189,760**	**244,300**	**196,200**	**132,360**	**759,070**
Local	98,150	148,180	99,430	86,370	428,330
Express Buses & Ferries	28,730	17,150	27,390	8,400	81,660
Bus Rapid Transit	62,880	78,970	69,380	37,590	249,080
Transfer Rate	**1.43**	**1.36**	**1.42**	**1.33**	**1.38**
Summit Results in Hours of User Benefits	**69**	**58**	**76**	**28**	**230**
Passenger Miles	**2,209,730**	**2,053,310**	**2,262,140**	**1,016,460**	**7,541,640**
Avg. IV Transit Trip Length in Miles	5.05	3.79	4.81	3.37	4.32
Passenger Hours	**125,660**	**122,800**	**124,160**	**62,330**	**434,950**
Avg. IV Transit Trip Time in Minutes	17.2	13.6	15.8	12.4	14.93
Daily Adult Cash Fare	**$ 605,060**	**$ 587,354**	**$ 631,790**	**$ 317,095**	**$ 2,141,299**
Avg. Fare per Linked Trip	0.507	0.679	0.524	0.716	0.589

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Daily Comparisons

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	Observed (2004) Base Year (includes estimates of linked trips)	BASE (2004) Base Year	NBLD (2025) No-Build
Linked Transit Trips	**909,400**	**1,006,880**	**1,260,160**
Walk Access	780,200	863,790	1,093,440
Drive Access	129,200	143,090	166,720
Auto Person Trips	10,052,130	11,233,200	12,300,090
Walking Person Trips	2,029,900	2,266,620	2,607,710
Total Person Trips	12,991,430	14,506,700	16,167,960
Transit Mode Share	7.0%	6.94%	7.79%
Unlinked Transit Trips	**1,209,500**	**1,343,920**	**1,744,870**
Commuter Rail System	114,000	113,760	151,920
North Side	38,800	46,910	58,700
Newburyport/Rockport	15,200	19,160	19,830
Haverhill	8,500	11,600	14,270
Lowell	7,400	6,880	10,140
West Medford Shuttle	na	na	na
Anderson Shuttle	na	na	na
Fitchburg	7,700	9,270	14,460
South Side	75,200	66,850	93,220
Framingham	15,200	14,260	19,310
Needham	8,800	5,470	6,160
Fairmont	2,400	5,080	12,080
Franklin	17,200	10,560	12,410
Attleboro	17,000	7,580	9,940
Stoughton	2,700	6,330	7,550
Middleboro	5,700	9,010	10,620
Plymouth	6,200	8,560	10,310
Greenbush	na	na	4,840
Rapid Transit System	722,200	812,360	833,100
Blue	64,700	68,820	70,540
Orange	170,000	163,180	166,300
Red	230,000	297,170	302,400
Green	257,500	283,190	293,860
Bus System	373,300	417,800	759,850
Local	327,300	348,110	429,000
Express Buses	33,000	57,990	82,110
Bus Rapid Transit	13,000	11,700	248,740
Transfer Rate	**1.33**	**1.33**	**1.38**
Summit Results in Hours of User Benefits	**na**	**na**	**na**
Daily Adult Cash Fare	**tbd**	**$ 1,637,728**	**$ 2,135,334**

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Daily Comparisons

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	**Alt. 4 (2025)**		**Alt. 1A (2025)**	
	TSM	**Diff. With NBLD**	**W. Medford - Green Line Ext**	**Diff. With NBLD**
Linked Transit Trips	**1,261,740**	**1,580**	**1,274,320**	**14,160**
Walk Access	1,095,030	1,590	1,106,000	12,560
Drive Access	166,710	-10	168,320	1,600
Auto Person Trips	12,298,700	-1,390	12,286,770	-13,320
Walking Person Trips	2,607,520	-190	2,606,870	-840
Total Person Trips	16,167,960	0	16,167,960	0
Transit Mode Share	7.80%	0.01%	7.88%	0.09%
Unlinked Transit Trips	**1,746,950**	**2,080**	**1,753,980**	**9,110**
Commuter Rail System	151,670	-250	150,180	-1,740
North Side	58,450	-250	56,890	-1,810
Newburyport/Rockport	19,810	-20	19,800	-30
Haverhill	14,250	-20	14,310	40
Lowell	10,020	-120	8,910	-1,230
West Medford Shuttle	na	na	na	na
Anderson Shuttle	na	na	na	na
Fitchburg	14,370	-90	13,870	-590
South Side	93,220	0	93,290	70
Framingham	19,310	0	19,340	30
Needham	6,160	0	6,160	0
Fairmont	12,080	0	12,080	0
Franklin	12,410	0	12,430	20
Attleboro	9,940	0	9,940	0
Stoughton	7,550	0	7,560	10
Middleboro	10,620	0	10,620	0
Plymouth	10,310	0	10,320	10
Greenbush	4,840	0	4,840	0
Rapid Transit System	831,930	-1,170	868,490	35,390
Blue	70,530	-10	71,600	1,060
Orange	165,940	-360	157,270	-9,030
Red	301,700	-700	281,880	-20,520
Green	293,760	-100	357,740	63,880
Bus System	763,350	3,500	735,310	-24,540
Local	432,790	3,790	410,530	-18,470
Express Buses	82,040	-70	81,120	-990
Bus Rapid Transit	248,520	-220	243,660	-5,080
Transfer Rate	**1.38**	**0.00**	**1.38**	**-0.01**
Summit Results in Hours of User Benefits	**relative to NBLD**	**700**	**relative to TSM**	**12,460**
Daily Adult Cash Fare	**$ 2,136,261**	**$ 927**	**$ 2,159,040**	**$ 23,706**

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Daily Comparisons

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	**Alt. 1C (2025)**		**Alt. 2B (2025)**	
	W. Medford / Union Sq - Green Line Ext.	**Diff. With NBLD**	**W. Medford BRT to Lechmere & Green Line to Union Sq.**	**Diff. With NBLD**
Linked Transit Trips	**1,270,220**	**10,060**	**1,270,750**	**10,590**
Walk Access	1,102,760	9,320	1,102,800	9,360
Drive Access	167,460	740	167,950	1,230
Auto Person Trips	12,290,430	-9,660	12,290,330	-9,760
Walking Person Trips	2,607,310	-400	2,606,880	-830
Total Person Trips	16,167,960	0	16,167,960	0
Transit Mode Share	7.86%	0.06%	7.86%	0.07%
Unlinked Transit Trips	**1,746,470**	**1,600**	**1,776,170**	**31,300**
Commuter Rail System	150,290	-1,630	150,710	-1,210
North Side	57,050	-1,650	57,480	-1,220
Newburyport/Rockport	19,790	-40	19,790	-40
Haverhill	14,290	20	14,280	10
Lowell	8,850	-1,290	8,950	-1,190
West Medford Shuttle	na	na	na	na
Anderson Shuttle	na	na	na	na
Fitchburg	14,120	-340	14,460	0
South Side	93,240	20	93,230	10
Framingham	19,310	0	19,310	0
Needham	6,160	0	6,160	0
Fairmont	12,080	0	12,080	0
Franklin	12,420	10	12,420	10
Attleboro	9,940	0	9,940	0
Stoughton	7,560	10	7,560	10
Middleboro	10,620	0	10,620	0
Plymouth	10,310	0	10,310	0
Greenbush	4,840	0	4,830	-10
Rapid Transit System	859,800	26,700	842,340	9,240
Blue	71,430	890	71,230	690
Orange	159,060	-7,240	159,880	-6,420
Red	283,330	-19,070	283,460	-18,940
Green	345,980	52,120	327,770	33,910
Bus System	736,380	-23,470	783,120	23,270
Local	413,000	-16,000	411,920	-17,080
Express Buses	81,020	-1,090	81,290	-820
Bus Rapid Transit	242,360	-6,380	289,910	41,170
Transfer Rate	**1.37**	**-0.01**	**1.40**	**0.01**
Summit Results in Hours of User Benefits	**relative to TSM**	**8,640**	**relative to TSM**	**8,070**
Daily Adult Cash Fare	**$ 2,151,933**	**$ 16,600**	**$ 2,154,838**	**$ 19,504**

Beyond Lechmere Study
DRAFT System Level Travel Demand Model Daily Comparisons

Avg. Daily System Wide Transit Measures (Urban Ring Assumed)	Alt. 3A (2025)		Alt. 3B (2025)	
	CRR Shuttle to W. Medford	Diff. With NBLD	CRR Shuttle to Anderson RTC	Diff. With NBLD
Linked Transit Trips	**1,261,830**	**1,670**	**1,262,050**	**1,890**
Walk Access	1,094,310	870	1,094,330	890
Drive Access	167,520	800	167,720	1,000
Auto Person Trips	12,298,480	-1,610	12,298,260	-1,830
Walking Person Trips	2,607,650	-60	2,607,650	-60
Total Person Trips	16,167,960	0	16,167,960	0
Transit Mode Share	7.80%	0.01%	7.81%	0.01%

Unlinked Transit Trips	**1,747,110**	**2,240**	**1,747,430**	**2,560**
Commuter Rail System	154,030	2,110	154,220	2,300
North Side	60,810	2,110	61,000	2,300
Newburyport/Rockport	19,830	0	19,830	0
Haverhill	14,110	-160	14,010	-260
Lowell	9,340	-800	5,840	-4,300
West Medford Shuttle	3,180	3,180	na	na
Anderson Shuttle	na	na	6,970	6,970
Fitchburg	14,350	-110	14,350	-110
South Side	93,220	0	93,220	0
Framingham	19,310	0	19,310	0
Needham	6,160	0	6,160	0
Fairmont	12,080	0	12,080	0
Franklin	12,410	0	12,410	0
Attleboro	9,940	0	9,940	0
Stoughton	7,550	0	7,550	0
Middleboro	10,620	0	10,620	0
Plymouth	10,310	0	10,310	0
Greenbush	4,840	0	4,840	0
Rapid Transit System	833,950	850	834,140	1040
Blue	70,590	50	70,600	60
Orange	166,590	290	166,690	390
Red	302,510	110	302,520	120
Green	294,260	400	294,330	470
Bus System	759,130	-720	759,070	-780
Local	428,340	-660	428,330	-670
Express Buses	81,770	-340	81,660	-450
Bus Rapid Transit	249,020	280	249,080	340

Transfer Rate	**1.38**	**0.00**	**1.38**	**0.00**
Summit Results in Hours of User Benefits	**relative to TSM**	**170**	**relative to TSM**	**230**
Daily Adult Cash Fare	**$ 2,138,197**	**$ 2,863**	**$ 2,141,299**	**$ 5,966**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	Base Year (2003)				
	AM	**MD**	**PM**	**NT**	**Daily**
Commuter Rail	**4,860**	**4,180**	**5,500**	**1,610**	**16,150**
Lowell	2,050	1,890	2,220	720	6,880
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	2,810	2,290	3,280	890	9,270
Rapid Transit	**31,800**	**42,800**	**36,320**	**30,510**	**141,430**
Green Line D Branch	22,950	26,310	25,440	19,020	93,720
Green Line E Branch	8,850	16,490	10,880	11,490	47,710
Bus Service	**7,640**	**14,120**	**8,610**	**6,880**	**37,250**
Route 80: Arlington Ctr - Lechmere	850	1,270	780	490	3,390
Route 87: Clar Hill - Lech via Somerville	460	920	570	910	2,860
Route 88: Clar Hill - Lech via Highland	850	1,250	650	660	3,410
Route 101: Malden Ctr - Sullivan	550	840	630	340	2,360
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	na	na	na	na	na
Rte 85	70	100	20	30	220
Rte 86	2190	4490	2320	1930	10,930
Rte 89	720	880	890	310	2,800
Rte 90	90	170	90	100	450
Rte 91	280	600	280	220	1,380
Rte 94	320	550	360	450	1,680
Rte 95	210	790	240	200	1,440
Rte 96	750	1520	1330	810	4,410
Rte 134	300	740	450	430	1,920
Corridor Level Unlinked Trips	**44,300**	**61,100**	**50,430**	**39,000**	**194,830**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	**No-Build (2025)**				
	AM	**MD**	**PM**	**NT**	**Daily**
Commuter Rail	**8,320**	**5,370**	**8,700**	**2,210**	**24,600**
Lowell	3,520	2,350	3,360	910	10,140
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,800	3,020	5,340	1,300	14,460
Rapid Transit	**33,340**	**42,720**	**36,980**	**33,540**	**146,580**
Green Line D Branch	22,810	24,730	25,030	19,070	91,640
Green Line E Branch	10,530	17,990	11,950	14,470	54,940
Bus Service	**9,060**	**16,510**	**10,160**	**10,290**	**46,020**
Route 80: Arlington Ctr - Lechmere	520	970	570	430	2,490
Route 87: Clar Hill - Lech via Somerville	490	910	550	880	2,830
Route 88: Clar Hill - Lech via Highland	580	1,090	460	570	2,700
Route 101: Malden Ctr - Sullivan	700	1,060	720	490	2,970
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	na	na	na	na	na
Rte 85	70	70	10	20	170
Rte 86	3,000	6,200	3,200	4,300	16,700
Rte 89	1,570	1,460	1,720	1,250	6,000
Rte 90	90	220	90	100	500
Rte 91	130	350	110	190	780
Rte 94	300	550	400	420	1,670
Rte 95	290	960	310	250	1,810
Rte 96	1,000	1,780	1,450	960	5,190
Rte 134	320	890	570	430	2,210
Corridor Level Unlinked Trips	**50,720**	**64,600**	**55,840**	**46,040**	**217,200**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	TSM (2025)				
	AM	MD	PM	NT	Daily
Commuter Rail	**8,280**	**5,340**	**8,630**	**2,140**	**24,390**
Lowell	3,500	2,320	3,330	870	10,020
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,780	3,020	5,300	1,270	14,370
Rapid Transit	**33,300**	**42,710**	**36,950**	**33,580**	**146,540**
Green Line D Branch	22,790	24,730	25,020	19,090	91,630
Green Line E Branch	10,510	17,980	11,930	14,490	54,910
Bus Service	**10,190**	**17,170**	**11,400**	**11,660**	**50,420**
Route 80: Arlington Ctr - Lechmere	910	1,200	1,060	1,070	4,240
Route 87: Clar Hill - Lech via Somerville	1,000	1,020	790	880	3,690
Route 88: Clar Hill - Lech via Highland	820	1,180	740	930	3,670
Route 101: Malden Ctr - Sullivan	1,030	1,300	1,180	1,100	4,610
Medford Hillside Circulator	40	160	70	80	350
West Medford BRT	na	na	na	na	na
Rte 85	60	70	10	10	150
Rte 86	2,970	6,180	3,180	4,270	16,600
Rte 89	1,320	1,380	1,510	1,120	5,330
Rte 90	80	220	90	110	500
Rte 91	120	340	100	180	740
Rte 94	290	550	390	410	1,640
Rte 95	270	930	300	180	1,680
Rte 96	980	1,760	1,420	920	5,080
Rte 134	300	880	560	400	2,140
Corridor Level Unlinked Trips	**51,770**	**65,220**	**56,980**	**47,380**	**221,350**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	Green Line to W. Medford (2025)				
	AM	MD	PM	NT	Daily
Commuter Rail	**8,090**	**4,810**	**8,120**	**1,760**	**22,780**
Lowell	3,420	1,920	2,930	640	8,910
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,670	2,890	5,190	1,120	13,870
Rapid Transit	**45,160**	**65,250**	**52,450**	**48,770**	**211,630**
Green Line D Branch	29,690	35,240	34,070	26,530	125,530
Green Line E Branch	15,470	30,010	18,380	22,240	86,100
Bus Service	**6,340**	**11,290**	**7,470**	**7,000**	**32,100**
Route 80: Arlington Ctr - Lechmere	240	350	250	110	950
Route 87: Clar Hill - Lech via Somerville	260	440	290	430	1,420
Route 88: Clar Hill - Lech via Highland	250	370	150	190	960
Route 101: Malden Ctr - Sullivan	330	510	300	220	1,360
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	na	na	na	na	na
Rte 85	60	60	10	10	140
Rte 86	2,890	5,770	3,000	3,840	15,500
Rte 89	610	510	820	540	2,480
Rte 90	60	130	60	60	310
Rte 91	110	260	80	130	580
Rte 94	120	260	140	200	720
Rte 95	130	370	130	110	740
Rte 96	1,020	1,500	1,760	820	5,100
Rte 134	260	760	480	340	1,840
Corridor Level Unlinked Trips	**59,590**	**81,350**	**68,040**	**57,530**	**266,510**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	**Green Line to W. Medford & Union Sq (2025)**				
	AM	**MD**	**PM**	**NT**	**Daily**
Commuter Rail	**8,140**	**4,860**	**8,190**	**1,780**	**22,970**
Lowell	3,410	1,900	2,910	630	8,850
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,730	2,960	5,280	1,150	14,120
Rapid Transit	**43,940**	**60,300**	**51,190**	**45,960**	**201,390**
Green Line D Branch	32,460	40,250	37,710	30,170	140,590
Green Line E Branch	11,480	20,050	13,480	15,790	60,800
Bus Service	**6,780**	**12,610**	**7,680**	**7,530**	**34,600**
Route 80: Arlington Ctr - Lechmere	250	440	260	140	1,090
Route 87: Clar Hill - Lech via Somerville	280	550	320	500	1,650
Route 88: Clar Hill - Lech via Highland	280	600	170	260	1,310
Route 101: Malden Ctr - Sullivan	400	660	330	250	1,640
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	na	na	na	na	na
Rte 85	60	60	10	10	140
Rte 86	2,920	5,860	3,050	3,910	15,740
Rte 89	870	820	950	710	3,350
Rte 90	70	180	60	80	390
Rte 91	110	260	80	130	580
Rte 94	130	320	150	220	820
Rte 95	150	490	140	130	910
Rte 96	990	1,560	1,670	830	5,050
Rte 134	270	810	490	360	1,930
Corridor Level Unlinked Trips	**58,860**	**77,770**	**67,060**	**55,270**	**258,960**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	W. Medford BRT to Lechmere & Green to Union Sq (2025)				
	AM	MD	PM	NT	Daily
Commuter Rail	**8,250**	**4,980**	**8,250**	**1,930**	**23,410**
Lowell	3,440	1,940	2,930	640	8,950
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,810	3,040	5,320	1,290	14,460
Rapid Transit	**40,160**	**54,690**	**44,990**	**42,380**	**182,220**
Green Line D Branch	26,810	30,280	29,720	23,370	110,180
Green Line E Branch	13,350	24,410	15,270	19,010	72,040
Bus Service	**15,600**	**27,675**	**18,550**	**17,750**	**79,575**
Route 80: Arlington Ctr - Lechmere	240	350	260	120	970
Route 87: Clar Hill - Lech via Somerville	280	450	320	440	1,490
Route 88: Clar Hill - Lech via Highland	260	390	160	210	1,020
Route 101: Malden Ctr - Sullivan	390	600	340	250	1,580
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	8,780	15,670	10,660	10,300	45,410
Rte 85	60	60	10	10	140
Rte 86	2,910	6,020	3,060	4,020	16,010
Rte 89	690	570	900	600	2,760
Rte 90	60	130	60	60	310
Rte 91	100	240	90	120	550
Rte 94	160	355	160	220	895
Rte 95	140	390	140	120	790
Rte 96	1,240	1,650	1,880	910	5,680
Rte 134	290	800	510	370	1,970
Corridor Level Unlinked Trips	**64,010**	**87,345**	**71,790**	**62,060**	**285,205**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	CRR Shuttle to W. Medford (2025)				
	AM	MD	PM	NT	Daily
Commuter Rail	**9,100**	**5,900**	**9,440**	**2,420**	**26,870**
Lowell	3,240	2,160	3,090	840	9,340
West Medford Shuttle	1,100	740	1,050	290	3,180
Anderson Shuttle	na	na	na	na	na
Fitchburg	4,760	3,000	5,300	1,290	14,350
Rapid Transit	**33,510**	**42,800**	**37,110**	**33,630**	**147,050**
Green Line D Branch	22,890	24,770	25,110	19,110	91,880
Green Line E Branch	10,620	18,030	12,000	14,520	55,170
Bus Service	**8,790**	**16,340**	**9,910**	**10,100**	**45,140**
Route 80: Arlington Ctr - Lechmere	500	960	540	410	2,410
Route 87: Clar Hill - Lech via Somerville	490	900	550	880	2,820
Route 88: Clar Hill - Lech via Highland	550	1,080	430	520	2,580
Route 101: Malden Ctr - Sullivan	660	1,030	700	460	2,850
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	na	na	na	na	na
Rte 85	60	50	10	20	140
Rte 86	3,000	6,200	3,200	4,300	16,700
Rte 89	1,510	1,420	1,660	1,220	5,810
Rte 90	90	220	90	100	500
Rte 91	130	350	110	190	780
Rte 94	270	540	370	400	1,580
Rte 95	290	960	300	250	1,800
Rte 96	970	1,770	1,420	940	5,100
Rte 134	270	860	530	410	2,070
Corridor Level Unlinked Trips	**51,400**	**65,040**	**56,460**	**46,150**	**219,060**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Results

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	CRR Shuttle to Anderson RTC (2025)				
	AM	MD	PM	NT	Daily
Commuter Rail	**9,170**	**5,940**	**10,620**	**3,010**	**27,160**
Lowell	2,020	1,340	3,070	800	5,840
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	2,410	1,600	2,290	950	6,970
Fitchburg	4,740	3,000	5,260	1,260	14,350
Rapid Transit	**33,560**	**42,800**	**37,150**	**33,650**	**147,160**
Green Line D Branch	22,920	24,770	25,130	19,120	91,940
Green Line E Branch	10,640	18,030	12,020	14,530	55,220
Bus Service	**8,800**	**16,300**	**9,880**	**10,080**	**45,060**
Route 80: Arlington Ctr - Lechmere	500	960	540	410	2,410
Route 87: Clar Hill - Lech via Somerville	490	900	550	880	2,820
Route 88: Clar Hill - Lech via Highland	550	1,080	430	520	2,580
Route 101: Malden Ctr - Sullivan	670	1,030	700	460	2,860
Medford Hillside Circulator	na	na	na	na	na
West Medford BRT	na	na	na	na	na
Rte 85	60	50	10	20	140
Rte 86	3,000	6,200	3,200	4,300	16,700
Rte 89	1,510	1,420	1,660	1,220	5,810
Rte 90	90	220	90	100	500
Rte 91	140	350	110	190	790
Rte 94	270	540	380	400	1,590
Rte 95	300	940	290	240	1,770
Rte 96	970	1,770	1,420	940	5,100
Rte 134	250	840	500	400	1,990
Corridor Level Unlinked Trips	**51,530**	**65,040**	**57,650**	**46,740**	**219,380**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Daily Comparisons

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	**Counts (2003)**	**BASE (2003)**	**NBLD (2025)**	**Alt. 4 (2025)**	
	Observed	**Base Year**	**No-Build**	**TSM**	**Diff. With NBLD**
Commuter Rail	**15,100**	**16,150**	**24,600**	**24,390**	**-210**
Lowell	7,400	6,880	10,140	10,020	-120
West Medford Shuttle	na	na	na	na	na
Anderson Shuttle	na	na	na	na	na
Fitchburg	7,700	9,270	14,460	14,370	-90
Rapid Transit	**125,000**	**141,430**	**146,580**	**146,540**	**(40)**
Green Line D Branch	na	93,720	91,640	91,630	-10
Green Line E Branch	na	47,710	54,940	54,910	-30
Bus Service	**32,300**	**37,250**	**46,020**	**50,420**	**4,400**
Route 80: Arlington Ctr - Lechmere	2,100	3,390	2,490	4,240	1750
Route 87: Clar Hill - Lech via Somerville	3,700	2,860	2,830	3,690	860
Route 88: Clar Hill - Lech via Highland	4,300	3,410	2,700	3,670	970
Route 101: Malden Ctr - Sullivan	4,200	2,360	2,970	4,610	1640
Medford Hillside Circulator	na	na	na	350	350
West Medford BRT	na	na	na	na	na
Rte 85	400	220	170	150	-20
Rte 86	5,100	10,930	16,700	16,600	-100
Rte 89	3,600	2,800	6,000	5,330	-670
Rte 90	1,300	450	500	500	0
Rte 91	1,500	1,380	780	740	-40
Rte 94	1,300	1,680	1,670	1,640	-30
Rte 95	1,700	1,440	1,810	1,680	-130
Rte 96	1,500	4,410	5,190	5,080	-110
Rte 134	1,600	1,920	2,210	2,140	-70
Corridor Level Unlinked Trips	**172,400**	**194,830**	**217,200**	**221,350**	**4,150**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Daily Comparisons

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	**Alt. 1A (2025)**		**Alt. 1C (2025)**		**Alt. 2B (2025)**	
	W. Medford - Green Line Ext	**Diff. With NBLD**	**W. Medford / Union Sq - Green Line Ext.**	**Diff. With NBLD**	**W. Medford BRT to Lechmere & Green to Union Sq.**	**Diff. With NBLD**
Commuter Rail	**22,780**	**-1,820**	**22,970**	**-1,630**	**23,410**	**-1,190**
Lowell	8,910	-1,230	8,850	-1,290	8,950	-1,190
West Medford Shuttle	na	na	na	0	na	na
Anderson Shuttle	na	na	na	0	na	na
Fitchburg	13,870	-590	14,120	-340	14,460	0
Rapid Transit	**211,630**	**65,050**	**201,390**	**54,810**	**182,220**	**35,640**
Green Line D Branch	125,530	33,890	140,590	48,950	110,180	18,540
Green Line E Branch	86,100	31,160	60,800	5,860	72,040	17,100
Bus Service	**32,100**	**-13,920**	**34,600**	**-11,420**	**79,580**	**33,560**
Route 80: Arlington Ctr - Lechmere	950	-1,540	1,090	-1,400	970	-1,520
Route 87: Clar Hill - Lech via Somerville	1,420	-1,410	1,650	-1,180	1,490	-1,340
Route 88: Clar Hill - Lech via Highland	960	-1,740	1,310	-1,390	1,020	-1,680
Route 101: Malden Ctr - Sullivan	1,360	-1,610	1,640	-1,330	1,580	-1,390
Medford Hillside Circulator	na	na	na	na	na	na
West Medford BRT	na	na	na	na	45,410	45,410
Rte 85	140	-30	140	-30	140	-30
Rte 86	15,500	-1,200	15,740	-960	16,010	-690
Rte 89	2,480	-3,520	3,350	-2,650	2,760	-3,240
Rte 90	310	-190	390	-110	310	-190
Rte 91	580	-200	580	-200	550	-230
Rte 94	720	-950	820	-850	900	-770
Rte 95	740	-1,070	910	-900	790	-1,020
Rte 96	5,100	-90	5,050	-140	5,680	490
Rte 134	1,840	-370	1,930	-280	1,970	-240
Corridor Level Unlinked Trips	**266,510**	**49,310**	**258,960**	**41,760**	**285,205**	**68,005**

Beyond Lechmere Study
DRAFT Corridor Level Travel Demand Model Daily Comparisons

Daily Corridor Level Transit Unlinked Trips (Urban Ring Project Assumed)	**Alt. 3A (2025)**		**Alt. 3B (2025)**	
	CRR Shuttle to W. Medford (2025)	**Diff. With NBLD**	**CRR Shuttle to Anderson RTC (2025)**	**Diff. With NBLD**
Commuter Rail	**26,870**	**2,270**	**27,160**	**2,560**
Lowell	9,340	-800	5,840	-4,300
West Medford Shuttle	3,180	3,180	na	na
Anderson Shuttle	na	na	6,970	6,970
Fitchburg	14,350	-110	14,350	-110
Rapid Transit	**147,050**	**470**	**147,160**	**580**
Green Line D Branch	91,880	240	91,940	300
Green Line E Branch	55,170	230	55,220	280
Bus Service	**45,140**	**-880**	**45,060**	**-960**
Route 80: Arlington Ctr - Lechmere	2,410	-80	2,410	-80
Route 87: Clar Hill - Lech via Somerville	2,820	-10	2,820	-10
Route 88: Clar Hill - Lech via Highland	2,580	-120	2,580	-120
Route 101: Malden Ctr - Sullivan	2,850	-120	2,860	-110
Medford Hillside Circulator	na	na	na	na
West Medford BRT	na	na	na	na
Rte 85	140	-30	140	-30
Rte 86	16,700	0	16,700	0
Rte 89	5,810	-190	5,810	-190
Rte 90	500	0	500	0
Rte 91	780	0	790	10
Rte 94	1,580	-90	1,590	-80
Rte 95	1,800	-10	1,770	-40
Rte 96	5,100	-90	5,100	-90
Rte 134	2,070	-140	1,990	-220
Corridor Level Unlinked Trips	**219,060**	**1,860**	**219,380**	**2,180**

Beyond Lechmere Study
DRAFT Daily Air Quality and Highway Measures from the Travel Demand Model

Avg. Daily System Wide AQ & Highway Measures (Urban Ring Assumed) & (MBTA Vehicle Emissions excluded)	NBLD (2025)	Alt. 4 (2025)		Alt. 1A (2025)		Alt. 1C (2025)	
	No-Build	TSM	Diff. With NBLD	W. Medford - Green Line Ext	Diff. With NBLD	W. Medford / Union Sq - Green Line Ext.	Diff. With NBLD
Air Quality Measures							
Volitie Organic Compounds in kg	32,053	32,049	-4	32,045	-8	32,048	-5
Nitrous Oxide in kg	31,422	31,422	0	31,404	-18	31,408	-14
Carbon Monoxide in kg	1,204,321	1,204,293	-28	1,203,766	-555	1,203,928	-393
Highway Measures							
Vehicle Miles of Travel	143,617,200	143,611,000	-6,200	143,552,700	-64,500	143,564,400	-52,800
Vehicle Hours of Travel	4,883,500	4,882,900	-600	4,878,800	-4,700	4,880,300	-3,200
Avg. Speed	29.41	29.41	0.00	29.42	0.02	29.42	0.01
Auto Person Trips Shifted to Transit	na	1,390	na	13,320	na	9,660	na
Auto Vehicle Trips Shifted to Transit	na	1,200	na	11,600	na	8,400	na
Trip Length of Vehicles Shifted to Transit	na		na		na		na

Emissions based on MOBILE 6a Factors (2005)

5.17

5.56

6.29

Beyond Lechmere Study
DRAFT Daily Air Quality and Highway Measures from the Travel Demand Model

Avg. Daily System Wide AQ & Highway Measures (Urban Ring Assumed) & (MBTA Vehicle Emissions excluded)	**Alt. 2B (2025)**		**Alt. 3A (2025)**		**Alt. 3B (2025)**	
	W. Medford BRT to Lechmere & Green to Union	**Diff. With NBLD**	**CRR Shuttle to W. Medford**	**Diff. With NBLD**	**CRR Shuttle to Anderson RTC**	**Diff. With NBLD**
Air Quality Measures						
Volitie Organic Compounds in kg	32,049	-4	32,050	-3	32,049	-4
Nitrous Oxide in kg	31,420	-2	31,419	-3	31,419	-3
Carbon Monoxide in kg	1,203,957	-364	1,204,311	-10	1,204,299	-22
Highway Measures						
Vehicle Miles of Travel	143,566,300	-50,900	143,609,600	-7,600	143,608,400	-8,800
Vehicle Hours of Travel	4,879,500	-4,000	4,882,800	-700	4,882,800	-700
Avg. Speed	29.42	0.01	29.41	0.00	29.41	0.00
Auto Person Trips Shifted to Transit	9,760	na	1,610	na	1,830	na
Auto Vehicle Trips Shifted to Transit	8,500	na	1,400	na	1,600	na
Trip Length of Vehicles Shifted to Transit		na		na		na

Emissions based on MOBILE 6a Factors (2005)

5.99

5.41

5.49

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